NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

THESIS

ANALYSIS OF THE U. S. MARINES CORPS' STEADY STATE MARKOV MODEL FOR FORECASTING ANNUAL FIRST-TERM ENLISTED CLASSIFICATION REQUIREMENTS

by

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March 1997

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REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE March 1997	3. REPORT TYPE AND DATES COVERED Master's Thesis

4. TITLE AND SUBTITLE TITLE OF THESIS.
ANALYSIS OF THE U. S. MARINE CORPS' STEADY STATE MARKOV MODEL FOR FORECASTING ANNUAL FIRST-TERM ENLISTED CLASSIFICATION REQUIREMENTS

5. FUNDING NUMBERS

6. AUTHOR Nguyen, Van Q.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Postgraduate School
Monterey CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Commandant of the Marine Corps (Code MPP-23)
Headquarters, U. S. Marine Corps, 2 Navy Annex
Washington, DC 20380-1775

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U. S. Government.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(maximum 200 words)*

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14. SUBJECT TERMS Manpower modeling, Classification, Markov model.

15. NUMBER OF PAGES 87

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18 298-102

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Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN SYSTEMS MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
March 1997

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ABSTRACT

The Marine Corps accesses approximately 29,000 to 36,000 new recruits annually. Determining how to classify these new enlistees into more than 200 Military Occupational Specialties is a critical task. These classification estimates must be precise, so the units within the Fleet Marine Force will have the necessary personnel to accomplish their mission. At the same time, these manpower planners must also balance the force structure to minimize personnel overages which could lead to excessive labor and training costs as well as promotion delays.

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TABLE OF CONTENTS

ACKNOWLEDGMENT

The author would like to acknowledge Major Brian Byrne, U. S. Marine Corps, for providing the thesis topic, data files, and background information used in this research study. The author wants to thank Professor Paul R. Milch for his valuable insight in analyzing the models and for his helpful advice throughout the course of this research. Recognition also goes to Professor Michael D. Cook for his assistance in reviewing the thesis. Additionally, the author applaud the technical support provided by Helen Davis and Dennis Mar from the Naval Postgraduate School's computer center, relating to the SAS coding utilized in this study. Lastly, the author appreciates the support and encouragement given by his loving wife, Joyce, and their two adoring daughters, Ashley and Jovanna.

I. INTRODUCTION

Manpower planning is the process of obtaining the correct number of people with the proper skills at the appropriate time in order to fulfill organizational human resource needs. The manpower planning activity contains two basic components: forecasting and programming. *Forecasting* involves generating the numbers, types, and qualities of personnel needed by an organization at some time in the future. *Programming* is the process and activities by which the forecast is implemented with much emphasis on development. [Ref. 1: p. 11] With human resources eating up over half of its annual budget, the Marine Corps is consistently looking at ways to attract, organize, and retain quality recruits to meet its end strength requirements and to accomplish its missions in the most cost-effective manner.[1] [Ref. 2] Thus, manpower planning becomes a critical task for the Marine Corps as it is for every major organization.

The purpose of this research is to assess, to refine, and to validate the steady state Markov model that is currently being utilized by the personnel planners at Headquarters, United States Marine Corps (HQMC) (Code MPP-23) to forecast the annual personnel classification and training requirements of new enlisted recruits. During the analysis, another steady state Markov model was developed to more accurately forecast their personnel classification and training requirements. This revised Markov model was designed to provide precise manpower forecasts in a much more timely fashion.

A. BACKGROUND

On an annual basis, the Marine Corps recruits approximately 29,000 to 36,000 new enlistees per year into its active-duty force. Forecasting the appropriate number of first-term (FTERM) personnel to access into the Marine Corps can become an overwhelming job due to the mere fact that the Marine Corps has over two hundred

[1] For Fiscal Year (FY) 1996 the budget for Military Personnel, Marine Corps was $5,779.2 millions compared to the total FY 1996 budget of $9,648.2 millions. The FY 1997 budget for Military Personnel, Marine Corps was $6,057.7 millions as compared to the total budget of $9,601.7 millions. The Military Personnel account does not include the spending for Reserve personnel.

Military Occupational Specialties (MOS) in which new enlistees must be admitted each year. Some MOS have more vacancy billets than others and some have higher entrance qualifications than others due to the technical background required in the job performance. Additionally, funding considerations, classification and assignment quotas, and primary MOS training requirements are also derived from this initial estimation.

Furthermore, there are legislative mandates for the Marine Corps to maintain an active-duty force of 174,000 Marines, including both the officers and enlisted personnel. [Ref. 3] Since Fiscal Year (FY) 1996, there is an added requirement that its personnel strength at the end of each FY cannot be more than ½ % below that specified maximum level and it cannot exceed that level by more than 1 %. [Ref. 4] Based on the manpower classification and training requirement forecasts, the recruiting command must allocate the enlistment quotas to the recruiters in the field to enlist new recruits who meet or exceed the qualifications for the particular MOS in question. Subsequently, the Marine recruit depots and the primary MOS schools are responsible for staffing their facilities to meet the anticipated training demands. Therefore, it is imperative that the predictions be as precise as possible to meet the legislative mandates and to ensure that the units within the Fleet Marine Force (FMF) will have the necessary personnel to accomplish their mission. At the same time, these manpower planners must balance the force structure to minimize wastage of training costs and to avoid personnel overages in a specific MOS because that will cause promotion delays due to possible "bottle-neck" effect in that occupation.

B. OBJECTIVES

The primary objective of this research is to determine if the current personnel classification and training model being used by the HQMC manpower planners is, in fact, the best steady state model for the Marine Corps to use in forecasting its enlisted personnel classification and training requirements. This research will provide a fair assessment of the Marine Corps' steady state Markov model and will seek to determine ways to improve its capability to forecast the annual classification for each individual Primary Military Occupational Specialty (PMOS). If the model is theoretically sound and

the solutions are feasible to implement and achieve in a relatively short period of time, then the Marine Corps is on the right track in its personnel planning process; however, if deficiencies are noted, the policy and/or the process must be changed to avoid unnecessary wastage of valuable human resources.

C. RESEARCH QUESTIONS AND METHODOLOGY

These are some of the questions that must be answered in the course of this research: Is the current steady state Markov model the most appropriate model? Is it theoretically sound? Does it represent the “real-world” training pipeline for the enlisted personnel? Are the attrition and continuation rates computed correctly? Are they relevant and justifiable? In order to answer the questions posed, the Marine Corps’ current steady state Markov model will be broken down into its basic components for a detailed analysis to examine the mathematical relationships between the components within the model and to ascertain the model’s strengths and weaknesses.

The main source of information regarding the current personnel forecasting procedures was obtained from personal interviews with the individuals who are actively engaged in the manpower planning process at HQMC. Additionally, a detailed analysis of their model on the Lotus spreadsheet revealed the process by which the classification forecasts were derived. HQMC (Code MPP-23) also provided the accession and separation data for the FY 1986 to FY 1996 cohorts in the 01 and 65 occupational fields. Thus, Statistical Analysis Software (SAS) was used to compute the yearly average continuation rates as well as to analyze the attrition and continuation patterns for the seven PMOS within these occupation fields. The steady state Markov model on the Lotus 1-2-3 spreadsheet being used by HQMC was evaluated in terms of its effectiveness and efficiency. Furthermore, a revised steady state Markov model was developed to more precisely predict the classification and training requirements for all the PMOS in which FTERM Marines are admitted.

D. SCOPE AND LIMITATIONS

This study will be focused on the assessment and refinement of the steady state Markov model that has been formulated by the manpower planners at HQMC (Code MPP-23). Historical accession and separation trends of seven enlisted PMOS will be examined by analyzing the FY 1986 to FY 1996 accession and separation cohort SAS data files, which were provided by the Marine Corps. Since there was no comprehensive written documentation made available to this researcher to substantiate the entire manpower planning process at the HQMC, there was a tremendous amount of reliance on the information obtained from personal interviews with the people who are actually involved with the current manpower planning process--in order to understand the personnel "forecasting" portion of the whole manpower projection concept.

E. ORGANIZATION OF THESIS

Chapter II presents a short literature review of the steady state Markov model and its basic theoretical framework. Chapter III describes how the Marine Corps uses the steady state Markov model to predict their personnel inventory and forecast their classification and training requirements. The assessment or critique of their model will also be included in this chapter. The revised steady state Markov model will be discussed in detail in Chapter IV. Similarities and differences will be noted between this revised model and the Marine Corps' current model. Chapter V contains the conclusions and recommendations from this research study. The User's Manual, the Lotus 1-2-3 spreadsheet programming, and the SAS codings, along with the outputs are provided in Appendices A to D, respectively.

II. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Within the field of management science, there are various forecasting techniques that are considered basic to manpower planning. Some, such as regression analyses, staffing (manning) tables, flow analyses, and the Delphi technique, have been used extensively in business manpower planning in the past. [Ref. 1:p. 145] The steady state Markov model, used in this thesis, belongs among the flow analyses technique. Since that is the main focus of this research effort, a brief literature review of the steady state Markov model is presented along with the model's relevant theoretical framework and some other pertinent issues.

A. LITERATURE REVIEW

According to Bartholomew et al., "It is almost a quarter of a century since the term 'manpower planning' came into general use but the statistical treatment of manpower systems must be as old as the planning of the military and the building exploits of the ancient world." [Ref. 5: p. 9] Vajda contends that "The earliest mathematical and statistical investigations relevant to forecasting the development of populations were due to actuaries; they go back to at least as far as Graunt in 1662." [Ref. 6] In the late 1800's, Andrey Markov, a Russian mathematician, introduced the concept of chained events that formed the basis for the theory of Markov chains and what we now refer to as the Markov model. [Ref. 7:p. 480] Furthermore, Batholomew et al. suggests that:

> there are two features of most manpower planning problems which render them suitable for statistical treatment. The first is the concern with aggregates. Manpower planning, unlike individual career planning, is concerned with numbers, that is, with having the right numbers in the right places at the right time. The second feature of manpower planning which calls for statistical expertise is the fact of uncertainty. This arises both from the uncertainty inherent in the social and economic environment in which the organization operates and from the unpredictability of human behavior. [Ref. 5:p. 1]

But regardless of the origin of the manpower planning concepts, we can tailor and utilize these mathematical models and scientific theories to solve some of the management problems that still plague many organizations today.

B. RELATED ISSUES

A more thorough description of the steady state Markov model is presented later in this chapter. But, for now, it is necessary to discuss a few of the topics which are important to our understanding of the Marine Corps' steady state Markov model.

1. PMOS Assignment

When an enlistee first enters the Marine Corps, he or she is initially assigned a basic PMOS such as 9900 or 9971. Those who are assigned a PMOS 9900 are the individuals who have signed an "open" enlistment contract, which means that the Marine Corps can later place them into any particular PMOS, depending on their gender and other qualifications. These new enlistees may request certain jobs, but the primary consideration in the assignment process is the "needs of the Marine Corps." Those individuals who were initially designated as 9971 have some sort of enlistment option or guarantee associated with their enlistment contract. [Ref. 8]

The diagram in Figure 2.1 shows the path that recruits generally follow after their enlistment.

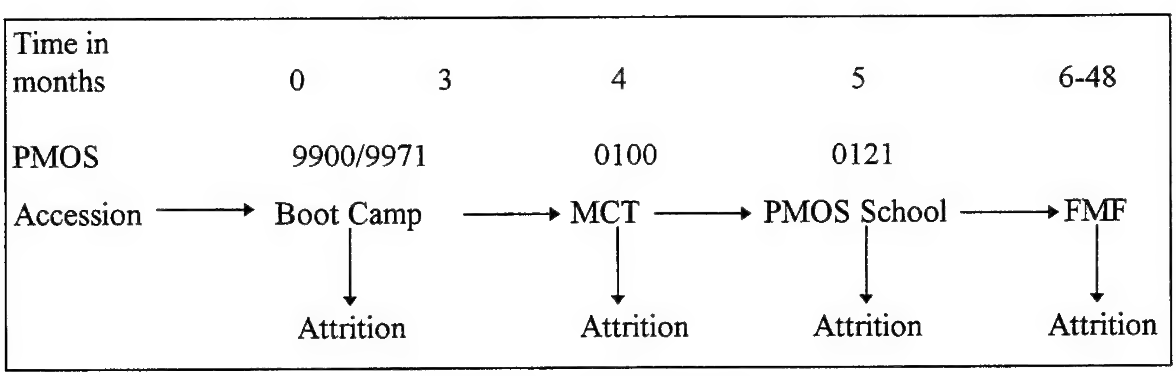


Figure 2.1. Career Path

Upon completion of boot camp training, which lasts for approximately three and a half months, these new Marines must also attend and successfully complete the Marine Combat Training (MCT) school before they can proceed to the next stage. By the tenth day of MCT, these new Marines are further classified into certain occupational fields and job skills, depending on their particular enlistment contract and the projected billet vacancies within the Marine Corps.

The example in Figure 2.1 shows a Marine who was classified into the 01 occupational field (OCCFLD), which is administration. The PMOS 0100 signifies that this Marine has a basic administrative skill level, because he or she has not attended formal training yet. His or her intended military occupational specialty (IMOS) at this point is 0121, which is a personnel clerk. After MCT, the new Marine is sent to admin-school, where he or she must also complete the required courses of instruction to qualify for that particular skill. Then the assignment of the IMOS becomes the permanent PMOS, and the Marine is usually transferred to a new duty station to fill a billet with a unit within the FMF. The time that each Marine spends in the training pipeline varies anywhere from one month to over one year, depending upon the number of courses and the school-seat availability for that particular PMOS. Notice that attrition can occur at any point along the career path. [Ref. 9:p. 4]

2. Organization or System

The organization or system depicted in this thesis is the body of personnel of FTERM, enlisted Marines. These are individuals who have less than four years of active-duty service. Those individuals with four years of service (YOS) or more, or serving in their second or subsequent re-enlistment contract are commonly referred to as careerists (CAREER) and will not be considered as part of the system for purposes of this thesis. The Marine Corps manages its FTERM and CAREER personnel structures separately; not only because of the differences in the billet requirements and experience-mix, but also because of the significant differences in their retention behavior. [Ref. 10:p. 307] As can

be expected, CAREER Marines are less likely to attrite than FTERM Marines, partly because they have invested more time in the organization.

3. Categorization

Within each OCCFLD, the FTERM Marines are further differentiated by specific specialty or skill level. For instance in the administration field, a Marine may be assigned a PMOS of:

0121 (Personnel Clerk)
0131 (Unit Diary Clerk)
0151 (General Administrative Clerk) or
0161 (Postal Clerk).

During their initial enlistment, these FTERM Marines generally do not transfer from one PMOS to another, so each PMOS can be analyzed independently from the others.

Additionally, these first-termers will be categorized by YOS as they progress through their military service in the Marine Corps. [Ref. 6:p. 5] In more precise terms, for a particular PMOS we shall categorize these FTERM Marines as follows:

Category 0	all the personnel entering the system during the FY
Category 1	all the personnel who entered the system during the previous FY but have not yet completed their first YOS
Category 2	all the personnel who have completed their first but not their second YOS
Category 3	all the personnel who have completed their second but not their third YOS
Category 4	all the personnel who have completed their third but not their fourth YOS.

Note that all the categories have been differentiated by a period of one year.

4. Stocks

Stocks are the number of personnel in a particular category at a given point in time. They provide a "snap-shot" of the personnel inventory within the organization. The stocks actually define the number of Marines with i YOS at the end of a FY, where $i = 0, 1, 2, 3, 4$. As shown in Figure 2.2, the stocks are as follows if we were to initially assign 100 Marines in the PMOS XXXX during a FY:

- the 100 Marines assigned to the PMOS are Category 0 personnel
- the 85 Marines at the end of the first YOS are Category 1 personnel
- the 75 Marines at the end of the second YOS are Category 2 personnel
- the 70 Marines at the end of the third YOS are Category 3 personnel
- and the 65 Marines at the end of the fourth YOS are Category 4 personnel.

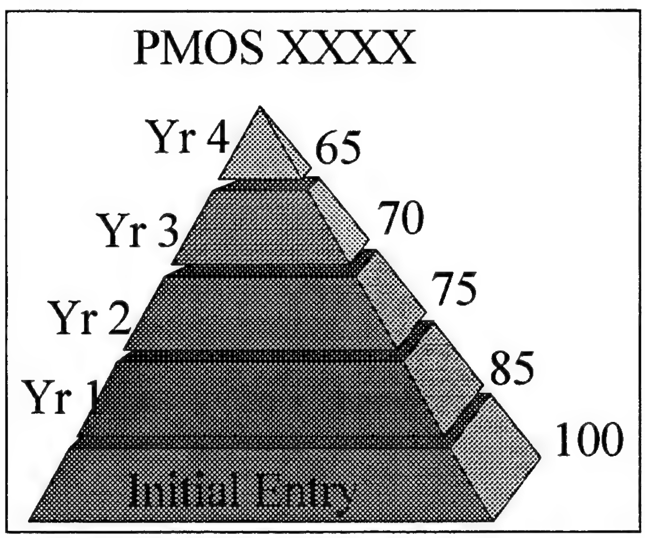


Figure 2.2. Sample Stocks

In general, the mathematical notation for these numbers is as follows:

n_i = the number of personnel in Category i at the end of the FY, for $i = 0, 1, 2, 3, 4$.

Using such data, we can calculate the yearly flow or continuation rates as explained in the next section.

5. Flow Rates

The number of personnel "moving" from one category to another during a period of time are often referred to as internal "flows," so the flow rates are the rate of personnel transitioning from one category to another during a FY. When categorization is done by YOS the only internal flow rates in the model which are not zero are the continuation rates, P_{ii+1}, which are the diagonal elements immediately above the main diagonal of the flow rate matrix, $\underline{P}$, as indicated below. [Ref. 11:p.17]

$$\underline{P} = \begin{bmatrix} 0 & P_{01} & 0 & 0 & 0 \\ 0 & 0 & P_{12} & 0 & 0 \\ 0 & 0 & 0 & P_{23} & 0 \\ 0 & 0 & 0 & 0 & P_{34} \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Here,

P_{01} = the fraction of Category 0 personnel who complete their first YOS within a FY

P_{12} = the fraction of Category 1 personnel who complete their second YOS within a FY

P_{23} = the fraction of Category 2 personnel who complete their third YOS within a FY

P_{34} = the fraction of Category 3 personnel who complete their fourth YOS within a FY

Note that following the method described by Bartholomew et al. [Ref. 5], the flow rate matrix, $\underline{P}$, does not contain the attrition rates $w_i = 1 - P_{ii+1}$, for i = 0, 1, 2, 3; and, in line with the restriction that the system consists of FTERM Marines only, $w_4 = 1$, implying that personnel who complete their fourth YOS must exit the system.

Continuing with the example from the previous section, the continuation rates can be calculated in the following manner:

Year 1 continuation rate = $P_{01} = n_1 / n_0 = 85/100 = .8500$

Year 2 continuation rate = $P_{12} = n_2 / n_1 = 75/85 = .8823$

Year 3 continuation rate = $P_{23} = n_3 / n_2 = 70/75 \ = .9333$

Year 4 continuation rate = $P_{34} = n_4 / n_3 = 65/70 \ = .9285$

This is an overly simplified example of how to compute the continuation rates, which applies only in a system that has reached steady state. Steady state implies that the stock levels no longer change from one FY to the next. [Ref. 5] The continuation rates actually used in the steady state Markov model in Chapters III and IV are derived from historical averages or weighted-averages of several cohorts and will be discussed at length in those chapters.

As explained above in a YOS model, attrition rates are computed from the continuation rates or vice versa. It is also important to note that the Marine Corps makes a distinction between the terms "attrition" and "separation." The term *attrition* is generally referred to as unplanned departure, while the word *separation* is usually reserved for planned or normal types of discharges from the Marine Corps. If a Marine separates before the end of his or her enlistment contract, then that is considered an attrition from the Marine Corps. However, for the purposes of this thesis there is no distinction between these two terms. Both are considered as attrition from the system.

6. Recruitment and Recruitment Vector

The term recruits refers to new entries into the system from the "outside world." Among many other names, new enlistees who enter the Marine Corps are often called recruits or boots. In our steady state Markov model, recruitment is composed of two factors. One is the total number of individuals who were initially assigned into that particular PMOS during the FY. The other factor is the recruitment proportion vector which indicates the distribution $(r_0, r_1, r_2, r_3, r_4)$ of the total recruitment population among the categories. For that reason the sum of the elements of the recruitment proportion vector must be equal to one. Since the Marine Corps is planning to access and classify only non-prior-service personnel from the civilian population, they are making the explicit assumption that r_0 is equal to one and the rest of the components are all equal to zeros.

However, if the personnel policy was to also recruit 10 percent with less than 1 YOS and 5 percent with less than 2 YOS personnel, then the distribution would be as follows: $r_0 = .85$, $r_1 = .10$, $r_2 = .05$, and $r_3 = r_4 = 0$.

C. THEORETICAL FRAMEWORK

A manpower model is a mathematical description of how change takes place in a personnel system. In many instances this requires the specification of constraints under which the system operates. The steady state aspect of a Markov model is generally presented by the following mathematical equation:

$$\underline{n}(\underline{I}-\underline{P})=R\underline{r} \tag{2.1}$$

Stock vector

Identity Matrix

Transition Rate Matrix

Total Recruitment

Recruitment Proportion Vector

The formula is comprised of the five elements shown in Equation (2.1). When the formula is expanded to represent the flow of a FTERM personnel system, it is given by the expression below:

$$(n_0,n_1,n_2,n_3,n_4)\left(\begin{bmatrix}1&0&0&0&0\\0&1&0&0&0\\0&0&1&0&0\\0&0&0&1&0\\0&0&0&0&1\end{bmatrix}-\begin{bmatrix}0&p_{01}&0&0&0\\0&0&p_{12}&0&0\\0&0&0&p_{23}&0\\0&0&0&0&p_{34}\\0&0&0&0&0\end{bmatrix}\right)=R(r_0,r_1,r_2,r_3,r_4). \tag{2.2}$$

Here,

n - is the *stock vector* or the size of the personnel force at any given time.

I - is the 5X5 *identity matrix*, i.e. a 5 by 5 matrix with 1's in the main diagonal and zeros everywhere else.

P - is the *transition rate matrix*, whose elements are the internal "flow rates" that govern the movement of personnel during a FY.

R - is the total number of recruitment during one FY.

r - is the recruitment proportion vector whose components show the way total recruitment is distributed into the five categories. [Ref. 11:p. 1-3]

In the next chapter we show how the Marine Corps manpower planners use these formulas to forecast the number of recruits to classify into each PMOS.

III. HQMC STEADY STATE MARKOV MODEL

In this chapter, we examine the HQMC's steady state Markov model from a formal mathematical perspective and check the primary model components to ensure that the values used in the model in forecasting classification requirements are valid and justifiable. Furthermore, we show how the manpower planners are using the model on the Lotus 1-2-3 spreadsheet to assist them in producing the classification forecasts across all the PMOS. Finally, we will provide an assessment of the strengths and weaknesses in their model as well as the effectiveness and efficiency of their spreadsheet.

A. THEORETICAL PERSPECTIVE OF HQMC'S STEADY STATE MARKOV MODEL

The HQMC's steady state Markov model is identical to the theoretical model that was presented in Chapter II. If we were to solve the equations manually to determine the yearly classification forecasts, we would perform the following steps:

First, we take the model's mathematical equation and expand it to represent the actual flow of FTERM Marines in the real world. Equation (2.2) becomes

$$(n_0, n_1, n_2, n_3, n_4)\begin{bmatrix} 1 & -p_{01} & 0 & 0 & 0 \\ 0 & 1 & -p_{12} & 0 & 0 \\ 0 & 0 & 1 & -p_{23} & 0 \\ 0 & 0 & 0 & 1 & -p_{34} \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} = R(1,0,0,0,0) \tag{3.1}$$

Here, we are making use of the fact that the Marine Corps recruits only non-prior-service personnel, *i.e.*, $r_0 = 1$ and $r_i = 0$ for $i = 1, 2, 3, 4$.

The next step is to perform the matrix multiplication indicated above. The result is the five equations below:

Equation 1: $(1)n_0 + (0)n_1 + (0)n_2 + (0)n_3 + (0)n_4 = R(1)$

$$\text{or } n_0 = R \tag{3.2}$$

$$\text{Equation 2: } (-p_{01})n_0 + (1)n_1 + (0)n_2 + (0)n_3 + (0)n_4 = R(0)$$

$$\text{or } n_1 = (p_{01})n_0 \tag{3.3}$$

$$\text{Equation 3: } (0)n_0 + (-p_{12})n_1 + (1)n_2 + (0)n_3 + (0)n_4 = R(0)$$

$$\text{or } n_2 = (p_{12})n_1 \tag{3.4}$$

$$\text{Equation 4: } (0)n_0 + (0)n_1 + (-p_{23})n_2 + (1)n_3 + (0)n_4 = R(0)$$

$$\text{or } n_3 = (p_{23})n_2 \tag{3.5}$$

$$\text{Equation 5: } (0)n_0 + (0)n_1 + (0)n_2 + (-p_{34})n_3 + (1)n_4 = R(0)$$

$$\text{or } n_4 = (p_{34})n_3 \tag{3.6}$$

The sixth equation expresses a constraint which specifies that the system size or the sum of the stocks must equal the billet requirement for the PMOS.

$$\text{Equation 6: } (0)n_0 + (1)n_1 + (1)n_2 + (1)n_3 + (1)n_4 = N \tag{3.7}$$

Notice that in Equations (3.2) to (3.6), the estimate for one stock component is used to forecast the value of the next stock component. Since the continuation rates are given in decimals which are multiplied into large numbers, there is a potential for rounding errors in the forecasts. In the next section, these equations are used in a Lotus spreadsheet to calculate the number of Marines to be classified into each PMOS on an annual basis.

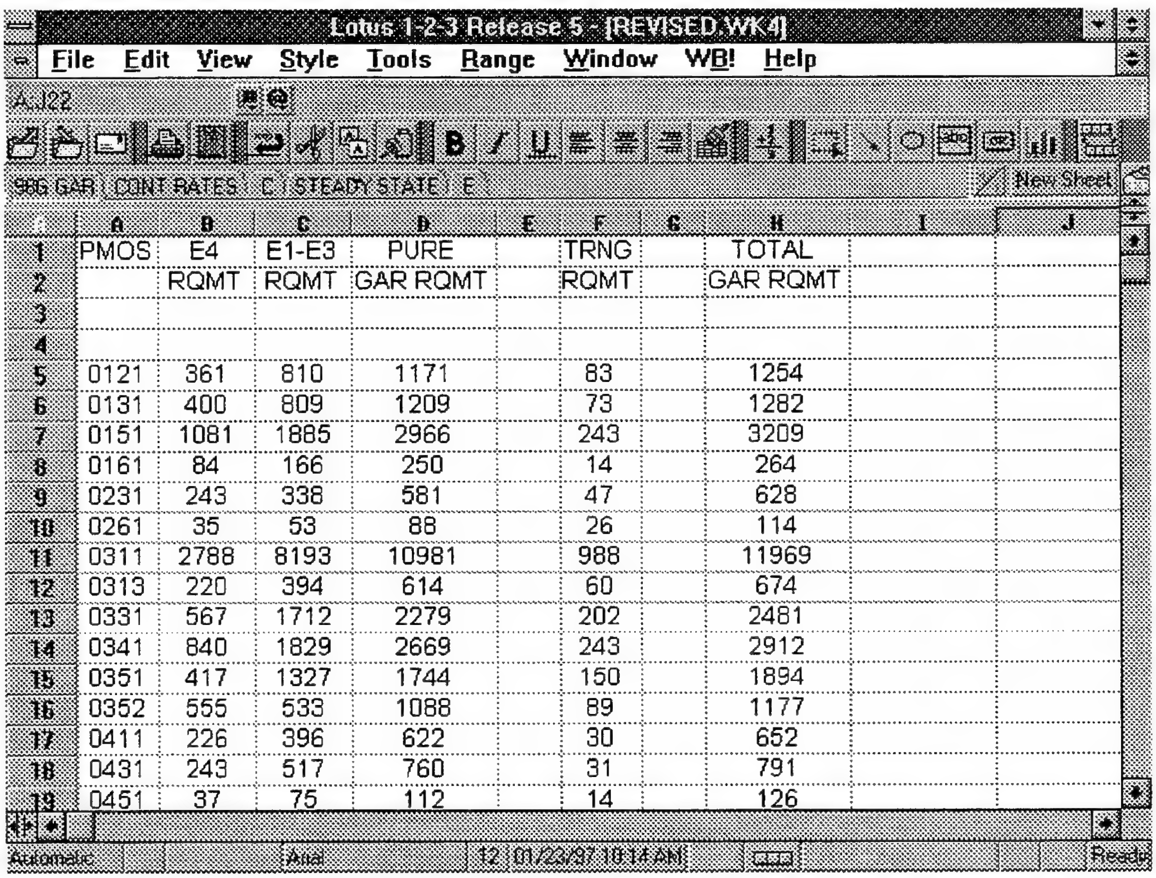
B. MAIN MODEL COMPONENTS

In this steady state Markov model, the three main components are the total requirement (*N*), the continuation rates $(P_{01}, P_{12}, P_{23}, P_{34})$, and the recruitment proportion vector $(r_0, r_1, r_2, r_3, r_4)$. The total requirement, the continuation rates, and the recruitment proportion vector are known factors. The total recruitment (*R*) and the stock vector $(n_0, n_1, n_2, n_3, n_4)$ are computed from the above three variables. Each of the three main

components will be discussed in detail, so we can see later how the steady state Markov model calculates the annual number of personnel to classify into each of the PMOS.

1. Total Billet Requirement

We now present the spreadsheet representation of the steady state Markov model used by HQMC. The total billet requirement for the PMOS is often referred by the manpower planners at HQMC as the Grade Adjusted Recapitulation (GAR) quantity. Column A of the spreadsheet in Figure 3.1 lists all the PMOS that these FTERM Marines may be admitted into.



PMOS	E4 RQMT	E1-E3 RQMT	PURE GAR RQMT	TRNG RQMT	TOTAL GAR RQMT
0121	361	810	1171	83	1254
0131	400	809	1209	73	1282
0151	1081	1885	2966	243	3209
0161	84	166	250	14	264
0231	243	338	581	47	628
0261	35	53	88	26	114
0311	2788	8193	10981	988	11969
0313	220	394	614	60	674
0331	567	1712	2279	202	2481
0341	840	1829	2669	243	2912
0351	417	1327	1744	150	1894
0352	555	533	1088	89	1177
0411	226	396	622	30	652
0431	243	517	760	31	791
0451	37	75	112	14	126

Figure 3.1. GAR Requirements

The 01 OCCFLD comprises the administrators in the Marine Corps, while the 02 OCCFLD represents all the intelligence PMOS. The Military Occupational Specialties (MOS) Manual lists all of the PMOS codes in the Marine Corps as well as their billet descriptions and the qualification and training requirements for them. [Ref. 8] For each PMOS, there is a specific total number of billet requirement as shown in column H. Figure 3.1 also shows that the FTERM billet requirement for PMOS 0121 is

E4 RQMT	+	E1-E3 RQMT	=	PURE GAR RQMT
361	+	810	=	1171

The E4 requirement of 361 and the E1-E3 requirement of 810 are the actual billet requirements for the first-termers in those pay grades. The combined total of these two numbers gives us a pure requirement of 1171. However, the total requirement for a particular PMOS also takes into account the approximate number of billets that are associated with training as shown in column F of Figure 3.1; namely:

PURE GAR RQMT	+	TRNG RQMT	=	TOTAL GAR RQMT
1171	+	83	=	1254

Thus, for PMOS 0121, the total requirement is actually 1254, which is the sum of the pure requirement of 1171 and the training requirement of 83. The training requirement is based on three critical factors: the amount of time spent in the training pipeline, the number of billets in the PMOS as compared to all the other PMOS, and the total initial-skill training billets authorized from budgetary constraints.

2. Weighted-average Continuation Rates

The yearly continuation rate is a another critical element, because in a "steady state" environment, we are making an assumption that conditions with respect to

continuation/attrition are similar from one year to the next. So, the continuation rates used in the steady state Markov model should be based on some reliable historical continuation rate data. Using SAS, the manpower planners at HQMC computed the yearly continuation rates for each cohort by PMOS and YOS.

Once the continuation rates for the different cohorts in a particular PMOS have been computed, a weighted-average method is utilized to compute the steady state continuation rates. For example, when the data set has cohorts from FY 1986 through 1995 available, the continuation rates that are computed for any PMOS is noted by an "x" in the appropriate block in Table 3.1 below:[2]

Cohort	Year 1	Year 2	Year 3	Year 4
1986	x	x	x	x
1987	x	x	x	x
1988	x	x	x	x (1)
1989	x	x	x (1)	x (2)
1990	x	x (1)	x (2)	x (3)
1991	x (1)	x (2)	x (3)	x (4)
1992	x (2)	x (3)	x (4)	
1993	x (3)	x (4)		
1994	x (4)			

Table 3.1. Weighted-average Continuation Rate Example

Their weighted-average continuation rates (CR) are computed by using the following formulas:

$$P_{01} = \text{Year 1 CR} = ((4*\text{CR1994})+(3*\text{CR1993})+(2*\text{CR1992})+(1*\text{CR1991}))/10$$

$$P_{12} = \text{Year 2 CR} = ((4*\text{CR1993})+(3*\text{CR1992})+(2*\text{CR1991})+(1*\text{CR1990}))/10$$

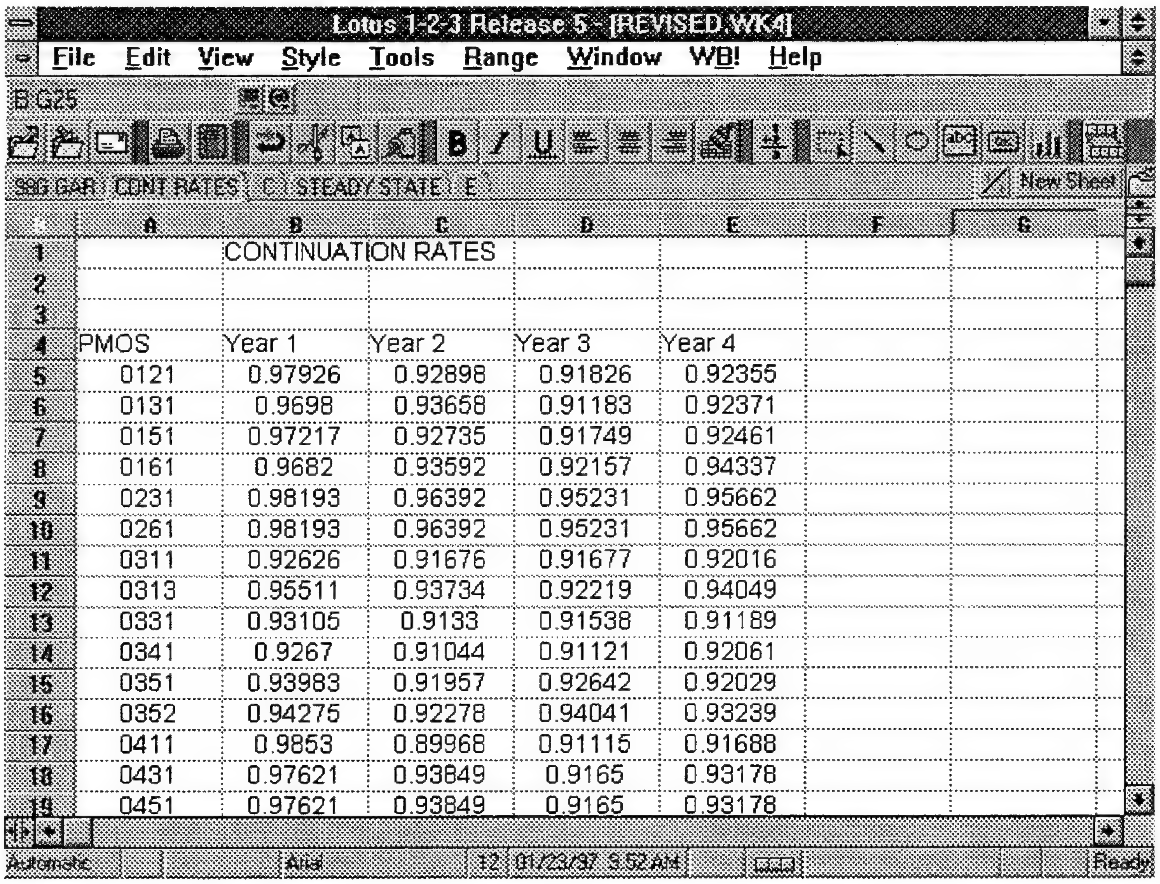
$$P_{23} = \text{Year 3 CR} = ((4*\text{CR1992})+(3*\text{CR1991})+(2*\text{CR1990})+(1*\text{CR1989}))/10$$

$$P_{34} = \text{Year 4 CR} = ((4*\text{CR1991})+(3*\text{CR1990})+(2*\text{CR1989})+(1*\text{CR1988}))/10$$

[2] The cutoff date for the data was August 1, 1996, so complete information on the FY 1996 cohort was not available.

For the Year 1 CR, the greatest weight of "4" is given to the most recent continuation rate data, which is currently from the FY 1994 cohort.[3] The weight of "3" is given to the next most recent continuation rate data, and so on. The sum of these values is divided by 10 to obtain the weighted-average continuation rate for year 1. The continuation rates for years 2, 3, and 4 are derived in a similar manner.[4]

Figure 3.2 contains HQMC's weighted-average yearly continuation rates.



	A	B	C	D	E
1		CONTINUATION RATES			
2					
3					
4	PMOS	Year 1	Year 2	Year 3	Year 4
5	0121	0.97926	0.92898	0.91826	0.92355
6	0131	0.9698	0.93658	0.91183	0.92371
7	0151	0.97217	0.92735	0.91749	0.92461
8	0161	0.9682	0.93592	0.92157	0.94337
9	0231	0.98193	0.96392	0.95231	0.95662
10	0261	0.98193	0.96392	0.95231	0.95662
11	0311	0.92626	0.91676	0.91677	0.92016
12	0313	0.95511	0.93734	0.92219	0.94049
13	0331	0.93105	0.9133	0.91538	0.91189
14	0341	0.9267	0.91044	0.91121	0.92061
15	0351	0.93983	0.91957	0.92642	0.92029
16	0352	0.94275	0.92278	0.94041	0.93239
17	0411	0.9853	0.89968	0.91115	0.91688
18	0431	0.97621	0.93849	0.9165	0.93178
19	0451	0.97621	0.93849	0.9165	0.93178

Figure 3.2. HQMC Weighted-average Continuation Rates

[3]The year 1 CR includes only the last three quarters of the first YOS. The FTERM Marines are usually classified into their particular OCCFLD around the tenth training day at MCT, which around the fourth month of service.

[4] In actuality, the year 4 CR comprises of only the first three quarters of the fourth YOS, because many FTERM Marines are often allowed to separate from the Marine Corps early to attending school or accept an appointment to a public office. Theses "early-outs" can be as far as 90 days before the end of their enlistment contract, so, if we do not take them in account, we would be over-estimating the total attrition from the Marine Corps.

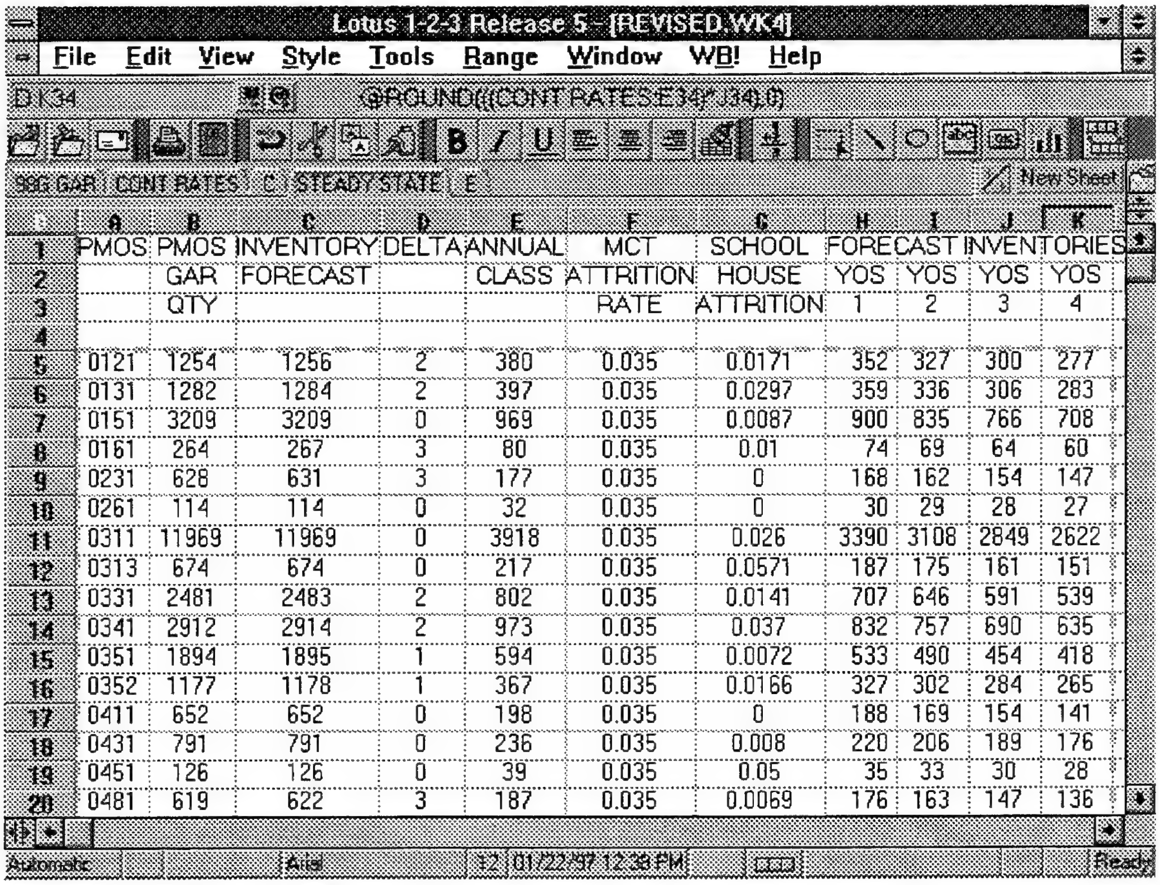
3. Recruitment Vector

Since the data files contained only Marines who were non-prior-service personnel, the manpower planners at HQMC made the explicit assumption that all the new recruitment were direct accessions from the civilian world with no previous military experience, *i.e.*, $r_0 = 1$ and $r_i = 0$ for $i = 1, 2, 3, 4$. In fact, less than five percent of the annual enlistees are prior-service personnel, so this is not a major concern to them. [Ref. 4] However, in reality when prior-service personnel with less than four YOS are allowed to enter into any of these PMOS, the classification forecasts may be affected, depending on the size of the total billet requirement and the number of prior-service personnel that have been authorized to join or re-enter the Marine Corps.

C. HOW DOES THE STEADY STATE MARKOV MODEL WORK?

The HQMC (Code MPP-23) provided the steady state Markov model on a Lotus 1-2-3 spreadsheet as shown in Figure 3.3.[5] The file also contains several other sheets with data such as total billet requirements (Figure 3.1) and continuation rates (Figure 3.2), which were directly linked to the steady state Markov model to simplify the calculations. Now, we can examine how the Marine Corps manpower planners utilize the equations derived from the steady state Markov model to forecast their annual classification requirements.

[5] The MPP department is the Manpower, Personnel & Policy department in the U. S. Marine Corps. The screen prints of the Lotus 1-2-3 spreadsheets are displayed exactly as you see them on the computer monitor but without the colors.



PMOS	PMOS GAR QTY	INVENTORY FORECAST	DELTA	ANNUAL CLASS	MCT ATTRITION RATE	SCHOOL HOUSE ATTRITION	FORECAST YOS 1	YOS 2	INVENTORIES YOS 3	YOS 4
0121	1254	1256	2	380	0.035	0.0171	352	327	300	277
0131	1282	1284	2	397	0.035	0.0297	359	336	306	283
0151	3209	3209	0	969	0.035	0.0087	900	835	766	708
0161	264	267	3	80	0.035	0.01	74	69	64	60
0231	628	631	3	177	0.035	0	168	162	154	147
0261	114	114	0	32	0.035	0	30	29	28	27
0311	11969	11969	0	3918	0.035	0.026	3390	3108	2849	2622
0313	674	674	0	217	0.035	0.0571	187	175	161	151
0331	2481	2483	2	802	0.035	0.0141	707	646	591	539
0341	2912	2914	2	973	0.035	0.037	832	757	690	635
0351	1894	1895	1	594	0.035	0.0072	533	490	454	418
0352	1177	1178	1	367	0.035	0.0166	327	302	284	265
0411	652	652	0	198	0.035	0	188	169	154	141
0431	791	791	0	236	0.035	0.008	220	206	189	176
0451	126	126	0	39	0.035	0.05	35	33	30	28
0481	619	622	3	187	0.035	0.0069	176	163	147	136

Figure 3.3. HQMC Steady State Markov Model

The information contained within each column is described in Table 3.2 on the next page.

Column	Title	Brief Description
A	PMOS	Primary Military Occupational Specialty (PMOS) or designated job skill code.
B	PMOS GAR QTY	PMOS Grade Adjusted Recapitulation (GAR) Quantity. This is the total billet requirement for the particular PMOS.
C	INVENTORY FORECAST	The estimated total personnel in the active-duty inventory for the PMOS.
D	DELTA	The difference between the INVENTORY FORECAST and the PMOS GAR QTY.
E	ANNUAL CLASS	The number of personnel expected to be classified into that PMOS on an annual basis.
F	MCT ATTRITION RATE	The anticipated attrition rate from Marine Combat Training (MCT) schools.
G	SCHOOL HOUSE ATTRITION	The anticipated attrition rate from the PMOS schools.
H to K	FORECAST INVENTORIES	The predicted inventories or survivors for each year of service (YOS): years 1, 2, 3 and 4.

Table 3.2. Description of Markov Model Data

The approach the manpower planners at HQMC use in determining the annual classification for each PMOS is demonstrated in detail below.[6] We use the formulas derived earlier in this chapter and the PMOS 0121 as an example to explain how the stocks are computed in their steady state Markov model on the Lotus 1-2-3 spreadsheet shown in Figure 3.3.

- **Estimation of n_0 and R:**

Recall that Equation (3.2) is $n_0 = R$, where n_0, depicted in Figure 3.3 as the Annual Class or the number of Category 0 personnel (entering the system from the outside world) for PMOS 0121 is equal to 380, as shown in cell E5 of the spreadsheet in Figure 3.3. Initially the number placed in this cell is a guess, but the calculations performed by

[6] In order to follow each of the steps, one must refer back to Figure 3.2 and Figure 3.3.

the spreadsheet will specify which direction the user must adjust the numerical value in this cell in order to arrive at the desired classification figure.

- **Computation of n_1:**

The second Equation (3.3) is $n_1 = (p_{01})n_0$, whereby n_1, the YOS 1 stock, is equal to the year 1 continuation rate times n_0. Thus, $n_1 = (.92716)380 = 352$ after rounding to the nearest integer as shown in cell H5 in Figure 3.3. The year 1 continuation rate is derived by taking the overall year 1 continuation rate (.97926) in cell H5 in Figure 3.2 and subtracting the MCT Attrition Rate (0.035) in cell F5 as well as the School House Attrition Rate (0.0171) in cell G5 in Figure 3.3.

- **Computation of n_2:**

The third Equation (3.4) in the steady state Markov model is $n_2 = (p_{12})n_1$, thus n_2, the YOS 2 stock, is equal to the year 2 continuation rate times n_1. The year 2 continuation rate is displayed in cell C5 in Figure 3.2. So, now $n_2 = (0.92898)352 = 327$ after rounding to the nearest integer as indicated in cell I5 in Figure 3.3.

- **Computation of n_3:**

The fourth Equation (3.5) is $n_3 = (p_{23})n_2$, so n_3, the YOS 3 stock, is equal to the year 3 continuation rate times n_2, or $n_3 = (0.91826)327 = 300$ after rounding to the nearest integer as displayed in cell J5 in Figure 3.3. The year 3 continuation rate is shown in cell D5 in Figure 3.2.

- **Computation of n_4:**

The fifth Equation (3.6) in the steady state Markov model is $n_4 = (p_{34})n_3$ where the YOS 4 stock, n_4, is equal to the year 4 continuation rate times n_3. Thus, n_4 = (0.92355)300 = 277 after rounding to the nearest integer as displayed in cell K5 in Figure 3.3. The year 4 continuation rate is cell E5 in Figure 3.2.

- **Computation of the Sum of the Stocks**

The last Equation (3.7) stipulates that the sum of the stocks must be equal to the billet requirement. In this case, the sum of the stocks is equal to $n_1 + n_2 + n_3 + n_4$ or 352+327+300+277 = 1256, which is displayed in cell C5 in Figure 3.3. Here, n_0 is <u>not</u>

added because these individuals are generally in a training or transition status and are not available for assignment to an "actual" billet until towards the end of their first YOS.

The manpower planners at HQMC have stream-lined many of these calculations by inserting certain formulas within specific spreadsheet cells to have the computer automatically perform the desired calculations. In their spreadsheet model, the information in column C (total inventory forecast), column D (delta), and columns H through K (yearly inventory forecasts) are automatically computed. The goal is to ensure that the total inventory forecast (column C) meets or exceeds the total billet requirement (column B). Column D is the delta or the difference between columns B and C. Notice for the PMOS 0121, the Marine Corps personnel planners predicted that they will have two more individuals in the inventory than the total billet requirement. Of course, this is only an estimate. In reality, there is no guarantee that the total inventory will be exactly as predicted by the model. Nevertheless, the primary reason for the difference between the total requirement and the estimated inventory forecast is due to rounding errors, because the continuation rates are decimals, and the equations are used successively in calculating the forecasts. At times, the estimates are accurate, but often they are classifying more personnel into the PMOS than what is really required.

Furthermore, about twice a year the total requirement for many of the PMOS may change as the Marine Corps restructures its force. With over 200 PMOS in which FTERM Marines may be admitted into, the forecasting process can become very time consuming because each Annual Class (input) value in column E must be adjusted up or down, so the newly forecasted inventory will meet or just exceed the new total requirement for that particular PMOS. The adjustment performed on all the numbers in column E of Figure 3.3 is done primarily by trial-and-error. The process may take the user an hour or more to complete the repetitive tasks in order to determine the new annual classification total across all the PMOS.

D. OVERALL ASSESSMENT

From a theoretical perspective, the manpower planners at HQMC are using the equations in the steady state Markov model properly, but some of the components within the model needs to be re-examined.

The first item that must be looked at closely is the weighted-average continuation rates. There are positive and negative consequences to using this method. On the positive side, it would seem reasonable to assume that the most recent continuation rate would be the most relevant and reliable information regarding military personnel's likelihood to continue their term of enlistment. However, if there is no consistency in the continuation rates from one year to the next, then there is a potential to over or under estimate the steady state continuation rates by giving greater emphasis and higher weights to the data from the most recent years. Using the data files provided by HQMC, we computed the yearly continuation rates for cohorts 1986 to 1994 for PMOS 0121 and 6521. As shown in the charts of Figures 3.4 and 3.5, the yearly continuation rates fluctuate from year to year with a roller-coaster effect.

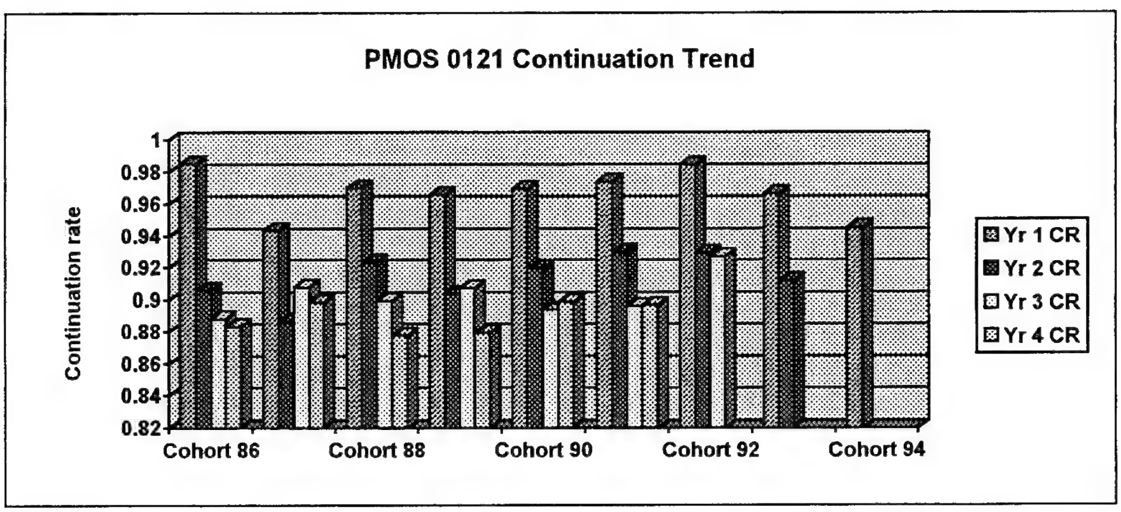


Figure 3.4. PMOS 0121 Continuation Trend

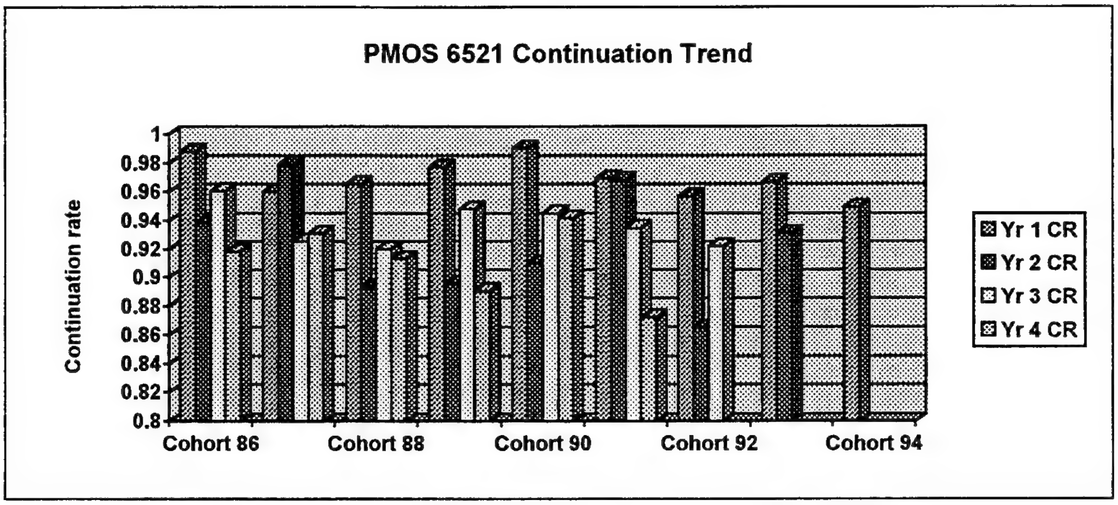


Figure 3.5. PMOS 6521 Continuation Trend

There is no consistent upward or downward trend, so it may be better to use the straight average continuation rates in the steady state Markov model to minimize the possibility of over or under estimating future continuation rates.

Also, the manpower planners at HQMC are slightly under-estimating their year 1 continuation rate by the way they are taking into account the attrition from MCT and the various school houses. They are currently subtracting the MCT and School House attrition rates from the overall year 1 continuation rate instead of multiplying by (1 - MCT Attrition) and (1 - School House Attrition) as is standard practice of applying continuation rates.[7] The difference in the two calculations may be numerically very minimal, but computing the continuation rate by the latter method is the proper approach.

Although many of the repetitive tasks are automated, their spreadsheet model is still very time-consuming to operate and the results are often imprecise due to the round-off errors associated with the successive calculations. According to Equation (3.7) in the steady state Markov model, the total inventory is supposed to be equal to the total billet

[7] The data used to compute the yearly continuation rates cannot account for those cases where the individual failed the first class and stayed to repeat a subsequent class or for those cases where the individual dropped from the school and was re-classified into another PMOS. Both of these cases are considered as attrition from the system, so the HQMC manpower planners decided to account for these situations by subtracting these attrition rates from the year 1 "overall" attrition rate. They would rather err by under-estimating the year 1 continuation rate and classify more Marines into the PMOS than to be caught with a shoratage of personnel.

requirement but as indicated in column D of Figure 3.3, the inventory forecast is often off by 1, 2, or 3 more than what the billets require.

In the next chapter, we demonstrate how the revised steady state Markov model corrects these short-comings to derive a more accurate and timely classification forecast for each of the PMOS.

IV. REVISED STEADY STATE MARKOV MODEL

In this chapter, we explain the mathematical approach that was used in the revised steady state Markov model to more accurately calculate the classification requirement for each PMOS. We will also illustrate how this new model operates differently from the current steady state Markov model on the Lotus 1-2-3 spreadsheet. Additionally, we demonstrate how the average continuation rates are computed with SAS and compare these rates with HQMC's weighted-average continuation rates. We conclude this chapter with an overall assessment of this revised model as compared to the current steady state Markov model.

A. THEORETICAL PERSPECTIVE OF THE REVISED STEADY STATE MARKOV MODEL AND THE MAIN MODEL COMPONENTS

The revised steady state Markov model contains the same components that was discussed in the HQMC's Markov model in Chapter III: namely the total requirements, the continuation rates, and the stock and recruitment proportion vectors. However, the main emphasis in developing this revised model is to improve the model's forecasting effectiveness and operational efficiency.

Instead of using the six equations derived from the steady state Markov model and multiplying them in a sequential fashion, we can also solve for the stocks in the following way:

First, we take the model's six basic equations as given by Equations (3.2) through (3.7) but in more general form, allowing for recruitment into all categories:

Equation 1: $(1)n_0 + (0)n_1 + (0)n_2 + (0)n_3 + (0)n_4 = R(r_0)$

Equation 2: $(-p_{01})n_0 + (1)n_1 + (0)n_2 + (0)n_3 + (0)n_4 = R(r_1)$

Equation 3: $(0)n_0 + (-p_{12})n_1 + (1)n_2 + (0)n_3 + (0)n_4 = R(r_2)$

Equation 4: $(0)n_0 + (0)n_1 + (-p_{23})n_2 + (1)n_3 + (0)n_4 = R(r_3)$

Equation 5: $(0)n_0 + (0)n_1 + (0)n_2 + (-p_{34})n_3 + (1)n_4 = R(r_4)$

$$\text{Equation 6: } (0)n_0 + (1)n_1 + (1)n_2 + (1)n_3 + (1)n_4 = N$$

After moving the recruitment (R) times the recruitment proportion (r_i) to the left-hand-side of the equal sign in each equation, we arrive at a system of six equations with six unknowns, namely, n_0, n_1, n_2, n_3, n_4 and R. As shown below, this system has the following elements: matrix $\underline{A}$ of coefficients, vector $\underline{b}$ of the values on the right-hand-side (RHS) of the equal signs, and vector $\underline{x}$ of the unknowns which are shown in the column headings.

$\underline{x}$

n_0	n_1	n_2	n_3	n_4	R	RHS
1	0	0	0	0	$-r_0$	0
$-P_{01}$	1	0	0	0	$-r_1$	0
0	$-P_{12}$	1	0	0	$-r_2$	0
0	0	$-P_{23}$	1	0	$-r_3$	0
0	0	0	$-P_{34}$	1	$-r_4$	0
0	1	1	1	1	0	N

$\underline{A}$ $\underline{b}$

The six equations may then be expressed in standard matrix-vector format as:

$$\underline{A} * \underline{x} = \underline{b}$$

The solution of this equation is:

$$\underline{x} = \underline{A}^{-1} * \underline{b} \tag{4.1}$$

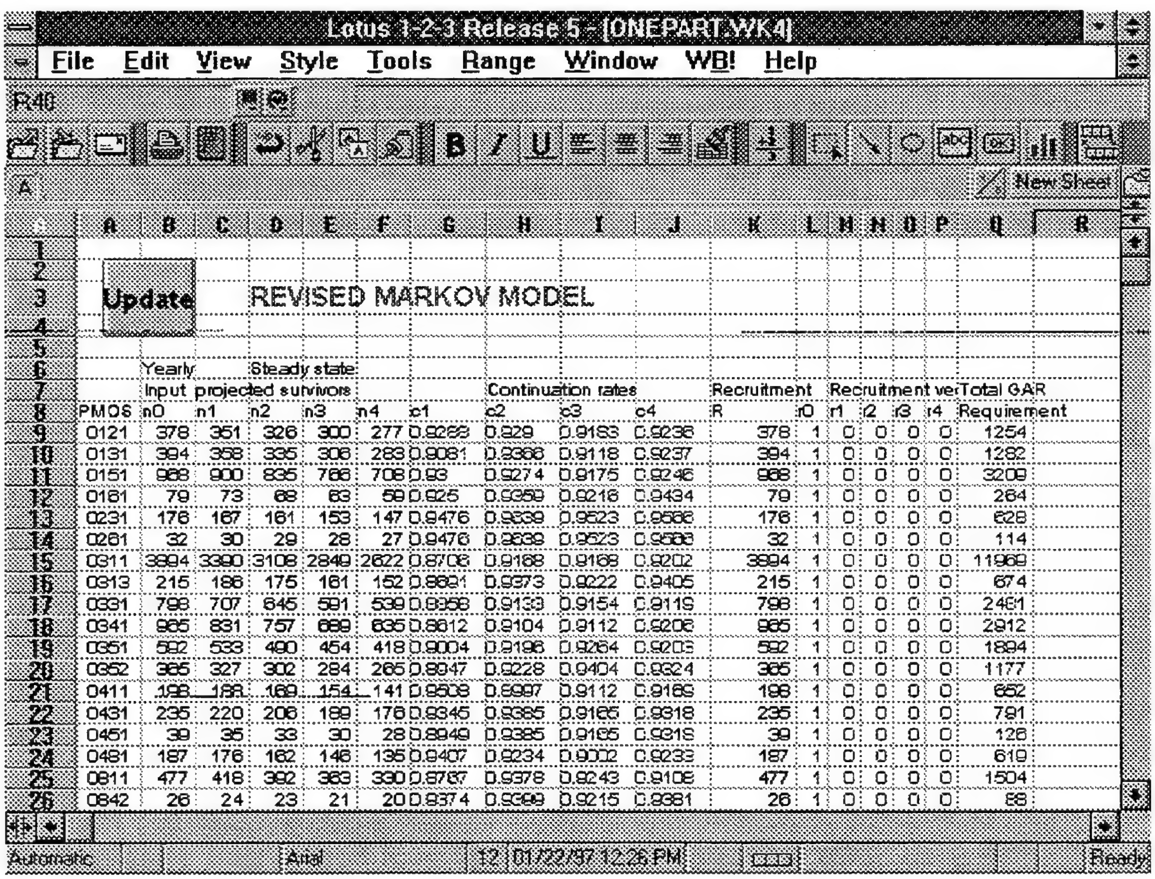
where $\underline{A}^{-1}$ denotes the inverse matrix associated with the matrix $\underline{A}$. [Ref. 12] As shown in Equation (4.1), the stocks and recruitment $(\underline{x})$ can be derived by multiplying the inverse of the matrix $\underline{A}$ by the vector $\underline{b}$.

Notice that the revised Markov model is constructed to be similar to the HQMC's steady state Markov model in that the same elements and fundamental equations are used to calculate the classification forecasts. However, by arranging the formula in the proper

manner and by taking advantage of some of the macro commands and other built-in tools within the spreadsheet software, we can compute the stocks and recruitment total with ease and complete accuracy. [Ref. 13] Appendix A contains the User's Manual for the spreadsheet with the revised model. Appendix B contains further details, pertaining to the process of setting up the six equations from the steady state Markov model in a spreadsheet to allow the computer to solve all the equations simultaneously in order to arrive at the correct solution of classifying the number of FTERM Marines into their particular PMOS. In the next section, we explain how this revised model actually works.

B. HOW DOES THE REVISED MARKOV MODEL WORK?

The spreadsheet with the revised steady state Markov model is presented in Figure 4.1.



	Yearly Input	Steady state projected survivors					Continuation rates			Recruitment	Recruitment vector					Total GAR
PMOS	n0	n1	n2	n3	n4	c1	c2	c3	c4	R	r0	r1	r2	r3	r4	Requirement
0121	378	351	326	300	277	0.9283	0.929	0.9183	0.9236	378	1	0	0	0	0	1254
0131	394	358	335	306	283	0.9081	0.9366	0.9118	0.9237	394	1	0	0	0	0	1282
0151	968	900	835	766	708	0.93	0.9274	0.9175	0.9246	968	1	0	0	0	0	3209
0161	79	73	68	63	59	0.925	0.9359	0.9216	0.9434	79	1	0	0	0	0	264
0231	176	167	161	153	147	0.9476	0.9639	0.9523	0.9566	176	1	0	0	0	0	628
0261	32	30	29	28	27	0.9476	0.9639	0.9523	0.9566	32	1	0	0	0	0	114
0311	3894	3390	3108	2849	2622	0.8706	0.9168	0.9168	0.9202	3894	1	0	0	0	0	11969
0313	215	186	175	161	152	0.8681	0.9373	0.9222	0.9405	215	1	0	0	0	0	674
0331	798	707	645	591	539	0.8858	0.9133	0.9154	0.9119	798	1	0	0	0	0	2481
0341	965	831	757	689	635	0.8612	0.9104	0.9112	0.9206	965	1	0	0	0	0	2912
0351	592	533	490	454	418	0.9004	0.9196	0.9264	0.9203	592	1	0	0	0	0	1894
0352	365	327	302	284	265	0.8947	0.9228	0.9404	0.9324	365	1	0	0	0	0	1177
0411	198	188	169	154	141	0.9508	0.8997	0.9112	0.9169	198	1	0	0	0	0	652
0431	235	220	206	189	176	0.9345	0.9365	0.9165	0.9318	235	1	0	0	0	0	791
0451	39	35	33	30	28	0.8949	0.9385	0.9165	0.9319	39	1	0	0	0	0	126
0481	187	176	162	146	136	0.9407	0.9234	0.9002	0.9233	187	1	0	0	0	0	619
0811	477	418	392	363	330	0.8767	0.9378	0.9243	0.9108	477	1	0	0	0	0	1504
0842	26	24	23	21	20	0.9374	0.9399	0.9215	0.9381	26	1	0	0	0	0	88

Figure 4.1. Revised Steady State Markov Model

This model was also developed on the Lotus 1-2-3 spreadsheet in order to accommodate the personnel managers at HQMC. This way the revised steady state Markov model can immediately be incorporated into HQMC's manpower planning process. It is a much more robust model, because it can now calculate the annual personnel classification for each PMOS more precisely and in a fraction of the time that it takes under the currently used model. Furthermore, the revised model can also take into account the data on prior-service personnel in its classification estimates.

The description of the information within each column is displayed in Table 4.1:

Column	Title	Brief Description
A	PMOS	Primary Military Occupational Specialty (PMOS) or designated job skill.
B	Yearly Input	The number of personnel classified into that PMOS on an annual basis, which is n_0. This number is equal to R, the Recruitment in column K.
C to F	Projected Survivors	The expected stocks for each year of service: n_1, n_2, n_3, n_4.
G to J	Continuation Rates	The continuation rates of (c_1, c_2, c_3, c_4) for years 1, 2, 3, and 4.
K	Recruitment	The total Recruitment equals the Yearly Input. Thus, $R = n_0$.
L to P	Recruitment Vector	Recruitment proportions for new as well as prior-service personnel: $(r_0, r_1, r_2, r_3, r_4)$.
Q	Total GAR Requirement	Total Grade Adjusted Recapitulation Requirement. This is the total billet requirement for the particular PMOS.

Table 4.1. Elements of the Revised Steady State Markov Model

In this spreadsheet, instead of manually adjusting the annual input for each PMOS, the user can just click an "Update" button in the upper, left-hand corner of the spreadsheet with the mouse, and the computer will automatically perform the necessary calculations to solve for the appropriate classification stocks $(n_0, n_1, n_2, n_3, n_4)$. The user

can adjust the continuation rates, the recruitment proportion vector, or the total billet requirement to any, a few, or all of the PMOS and by clicking on the "Update" button have the computer re-calculate the stocks and total annual classification within a matter of seconds.

As discussed in Chapter III, the manpower planners at HQMC used the weighted-average method of computing the continuation rates. There are other methods that can be used to determine the appropriate continuation rates to use in the steady state Markov model. The method chosen is a matter of preference, but it should also be supported by solid data and a sound logical basis. The average continuation rates, described in the next section, is often the preferred method to use in many steady state forecasts.

C. AVERAGE CONTINUATION RATES

To minimize the duplication of repetitive tasks for the purposes of this study, only seven PMOS from two OCCFLDs were examined closely. So, HQMC (Code MPP-23) provided a subset of their data file on two 3½" floppy diskettes. The two OCCFLDs were the 01 and 65, which are the administration and aviation ordnance OCCFLDs, respectively. The data files contained a total of 20,049 observations for the FY 1986 to FY 1996 cohorts. Each observation equates to an individual Marine who had entered and progressed through the FTERM, YOS system. Accession and separation data was provided along with some other personnel information. The files were up-loaded onto the Naval Postgraduate School's mainframe computer, and SAS coding was used to calculate the average continuation rates as well as to analyze the attrition and continuation patterns for those seven PMOS. The actual SAS coding used for this research study, along with a detailed explanation, is included in Appendix C. Also, the output such as the yearly survivors by each cohort and PMOS, the average continuation rates, and some other informative tables from the SAS programming are shown in Appendix D.

In my estimation, a straight average of the nine most recent years' continuation rates is a better set of continuation rates to use in the steady state Markov model, because it does not weight any one year more heavily than the others. Thus, the estimates are less

likely to be effected by sudden fluctuations in the yearly continuation rates. Using the computed average continuation rates in Appendix D, we may be able to compare the differences between these straight average continuation rates and HQMC's weighted-average continuation rates, which were provided to this researcher for the study. Figures 4.2 and 4.3 show that the year 1 weighted-average continuation rate is lower than the average continuation rate; however, the continuation rates for years 2, 3, and 4, based on the weighted-average method is higher than the average rates computed in this study.

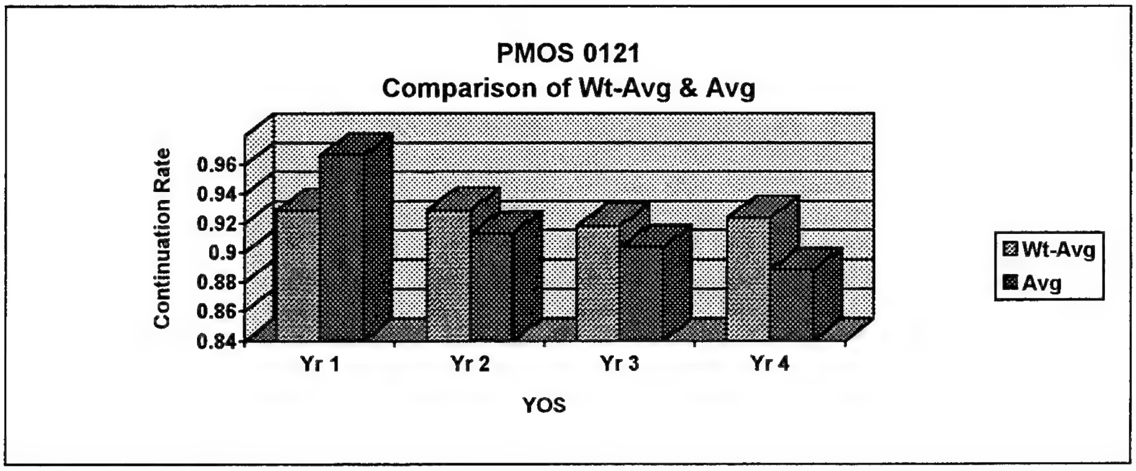


Figure 4.2. PMOS 0121 Comparison of Wt-Avg and Avg Continuation Rates

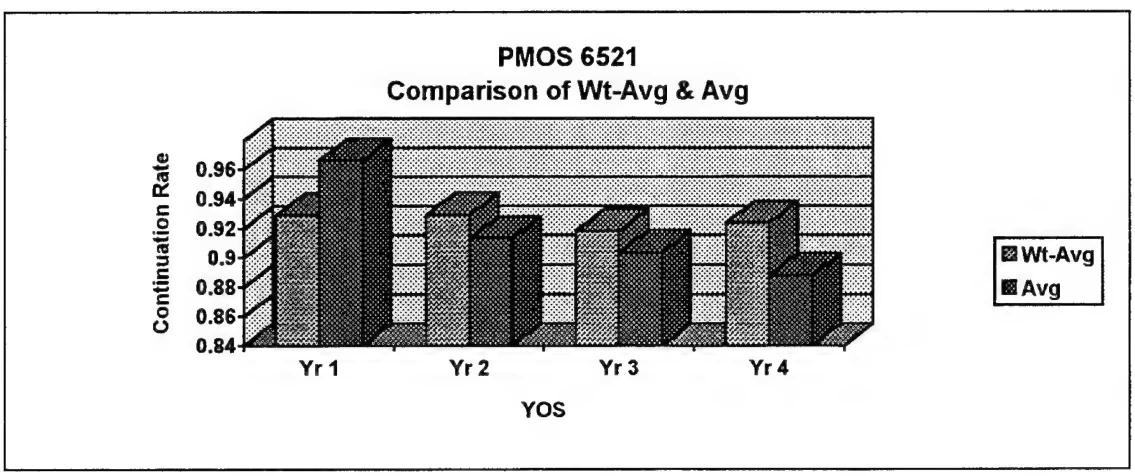


Figure 4.3. PMOS 6521 Comparison of Wt-Avg and Avg Continuation Rates

Although, the data on the seven PMOS used in this study was supposed to be a subset (restricted to the PMOS 0121, 0131, 0151, 0161, 6521, 6531, 6541) of the data that the manpower planners at HQMC used to compute their weighted-average continuation rates, we cannot perform an actual critique between these two methods because the data sets used in this analysis were not identical to theirs. For instance, in the data files that was used in this analysis, data pertaining to Marines who entered the Marine Corps with a contract length of less than four years were deleted. Without excluding these individuals, the year 3 and year 4 continuation rates would be underestimated. Additionally, Marines with the basic PMOS 9900 and 9971 had to be distributed to the appropriate OCCFLD. Furthermore, the Marines with the basic skill PMOS 0100 or 6500 had to be assigned to one of the appropriate PMOS within their OCCFLD. The procedures used to classify these Marines to the appropriate OCCFLD and PMOS is explained in Appendix C, along with other SAS codings, which were used to "clean-up" the data files.

By removing some individuals from the files, our calculations of the continuation rates are bound to be different from the ones used in the HQMC model. So, any comparison that is performed here is done for purposes of illustration only.

D. MODEL COMPARISON AND OVERALL ASSESSMENT

This revised steady state Markov model is very similar to the HQMC's model in theory, but the approach used here to solve the equations in the model to compute the stocks and recruitment was performed more efficiently and more generally. The revised model on the new spreadsheet provides a more accurate and timely forecast of the annual classification and training requirements. With the current steady state Markov model, the forecast of the total classification requirement calls for an annual input of 31,288 new recruits, while the revised model forecasts that only 31,023 new recruits is really necessary to fill the same total billet requirements. The difference between these two estimates is 265 "bodies." Thus, the revised model has the potential of saving the Marine Corps valuable resources in terms of labor and training costs. In addition, the revised Markov

model is more flexible because it can also include prior-service personnel data in the equations to derive an even more precise calculation of the classification forecast as well as the stock inventory.

V. CONCLUSIONS AND RECOMMENDATIONS

Based on the findings from this thesis research, the conclusions and some of the recommendations are provided below.

A. CONCLUSION

From a mathematical standpoint, the manpower planners at HQMC are using their current steady state Markov model largely correctly in computing the classification and training requirement of the FTERM Marines, except that some of the components within the model, such as the year 1 continuation rate, are not computed according to standard practice. As a consequence, the year 1 continuation rate is slightly under estimated across all the PMOS. Furthermore, the estimates of the classification stocks are imprecise due to rounding errors inherent in the way the forecasting process is carried out. Additionally, the weighted-average continuation rates may also over or under estimate the real continuation rate by placing greater emphasis on the most recent continuation rate data.

B. RECOMMENDATIONS

The recommendations provided below are suggestions to improve the current manpower planning process as well as an opportunity to encourage others to utilize the SAS and Lotus programming techniques to perfect the system and/or to refine the spreadsheets to eliminate redundancy.

1. Implement Revised Steady State Markov Model

It is recommended that the revised steady state Markov model be incorporated into HQMC's current manpower planning process to improve the accuracy and performance of the FTERM classification and training requirement forecasts. This model will also save time and labor costs because the calculations can be done in a much more

timely fashion. Also, this revised model can be used to do "what-if" analysis on the various PMOS due to possible changes in accession, classification, training or even recruiting policies. For example, if we wanted to forecast the appropriate number of Marines to classify into the PMOS 0121, given that 3 percent have less than 1 YOS, and 2 percent with less than 2 YOS, then all we need to do is change r_0 to (.95), r_1 to (.03), r_2 to (.02), and ensure that r_3 and r_4 are equal to zeros, then click the "Update" button. The new forecast will appear on the computer screen almost instantaneously. The steady state Markov model, currently being utilized by the HQMC manpower planners, was not configured to perform these sort of calculations.

2. Other Applications

In addition to forecasting the yearly classification stock numbers, this revised steady state Markov model can also be used to forecast FTERM accessions. These two separate functions could possibly be merged into a single process. Furthermore, although it would be a much more complex task, the concepts demonstrated for this YOS system could be expanded to model the Marine Corps' CAREER force structure. Additionally, the spreadsheet techniques and commands used in this study to create a macro button to enable the spreadsheet to compute the results automatically could be transferred to other spreadsheet models to streamline the computational processes and to maximize their performance.

3. Review Computation of the Weighted-average Continuation Rates

The method of computing the weighted-average continuation rates should be reviewed. Special attention should be given to the way in which the year 1 continuation rate is computed. The first YOS is a crucial time period, because this is where most of the attrition occurs. Since the continuation rates are one of the most critical elements in the steady state Markov model, it is important that the rates be reliable, and the approach used to obtain those rates be theoretically sound. The average continuation rates, as well as

some other methods, should be explored as viable alternatives to the currently used weighted-average rates.

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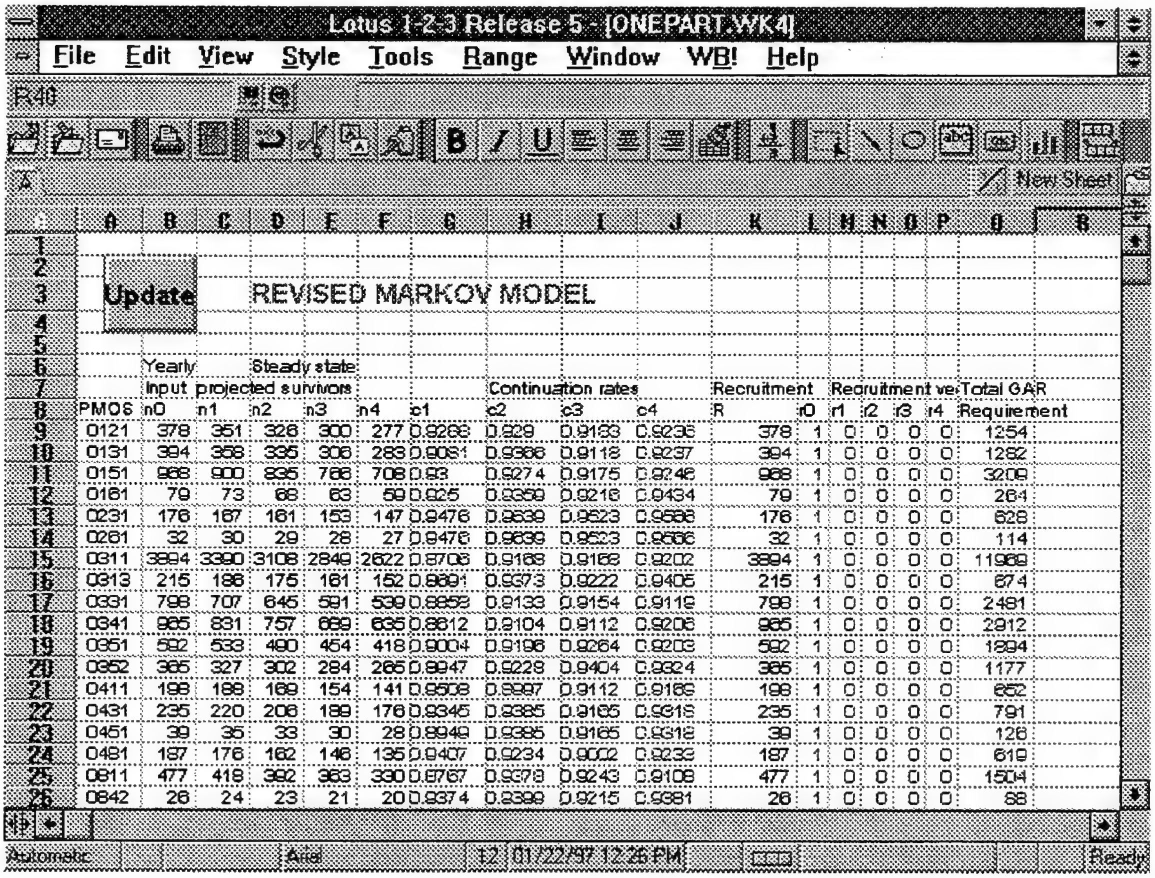
APPENDIX A. USER'S MANUAL

The instructions provided in this User's Manual will assist the operator in using the spreadsheet with the revised steady state Markov model to make precise classification forecasts. The spreadsheet was developed on Lotus 1-2-3 Release 5 for Windows. When the file "ONEPART.WK4" is opened, the spreadsheet which appears on the computer monitor resembles the screen print of Figure A.1.



	Yearly	Steady state														
	Input	projected survivors					Continuation rates			Recruitment		Recruitment ve				Total GAR
PMOS	n0	n1	n2	n3	n4	c1	c2	c3	c4	R	r0	r1	r2	r3	r4	Requirement
0121	378	351	326	300	277	0.9288	0.929	0.9183	0.9236	378	1	0	0	0	0	1254
0131	394	358	335	306	283	0.9081	0.9366	0.9118	0.9237	394	1	0	0	0	0	1282
0151	968	900	835	766	708	0.93	0.9274	0.9175	0.9246	968	1	0	0	0	0	3209
0161	79	73	68	63	59	0.925	0.9359	0.9218	0.9434	79	1	0	0	0	0	264
0231	176	167	161	153	147	0.9476	0.9639	0.9523	0.9588	176	1	0	0	0	0	628
0261	32	30	29	28	27	0.9476	0.9639	0.9523	0.9586	32	1	0	0	0	0	114
0311	3894	3390	3108	2849	2622	0.8706	0.9168	0.9168	0.9202	3894	1	0	0	0	0	11969
0313	215	186	175	161	152	0.8691	0.9373	0.9222	0.9405	215	1	0	0	0	0	674
0331	798	707	645	591	539	0.8859	0.9133	0.9154	0.9119	798	1	0	0	0	0	2481
0341	965	831	757	689	635	0.8612	0.9104	0.9112	0.9206	965	1	0	0	0	0	2912
0351	592	533	490	454	418	0.9004	0.9196	0.9264	0.9203	592	1	0	0	0	0	1894
0352	365	327	302	284	265	0.8947	0.9229	0.9404	0.9324	365	1	0	0	0	0	1177
0411	198	188	169	154	141	0.9508	0.9987	0.9112	0.9169	198	1	0	0	0	0	852
0431	235	220	206	189	176	0.9345	0.9385	0.9165	0.9319	235	1	0	0	0	0	791
0451	39	35	33	30	28	0.8949	0.9385	0.9165	0.9318	39	1	0	0	0	0	126
0481	187	176	162	146	135	0.9407	0.9234	0.9002	0.9233	187	1	0	0	0	0	619
0811	477	418	392	363	330	0.8767	0.9378	0.9243	0.9108	477	1	0	0	0	0	1504
0842	26	24	23	21	20	0.9374	0.9398	0.9215	0.9381	26	1	0	0	0	0	88

Figure A.1. Spreadsheet with the Revised Steady State Markov Model

A. WHAT ARE IN THE COLUMNS?

On an actual computer monitor, the numerical values in columns G through J and columns L through Q are displayed in blue color, suggesting that the user can adjust the values within these columns. The values in all the other columns are computed by the

program, and are displayed in black. A brief description of the information contained within each column is shown in Table A.1.

Column	Title	Brief Description
A	PMOS	Primary Military Occupational Specialty (PMOS) or designated job skill.
B	Yearly Input	The number of personnel classified into that PMOS on an annual basis, which is n_0. This number is equal to R, the Recruitment in column K.
C to F	Projected Survivors	The expected stocks for each year of service: n_1, n_2, n_3, n_4.
G to J	Continuation Rates	The continuation rates of (c_1, c_2, c_3, c_4) for years 1, 2, 3, and 4.
K	Recruitment	The total Recruitment equals the Yearly Input. Thus, $R = n_0$.
L to P	Recruitment Vector	Recruitment proportions for new as well as prior-service personnel: $(r_0, r_1, r_2, r_3, r_4)$.
Q	Total GAR Requirement	Total Grade Adjusted Recapitulation Requirement. This is the total billet requirement for the particular PMOS.

Table A.1. Elements of the Revised Steady State Markov Model

B. SPECIFIC INSTRUCTIONS

As indicated above, columns G to J contain the yearly continuation rates, which range from a value of 0 to 1. Although these rates can be modified by the user, they should not be adjusted too frequently in a steady state Markov model. Columns L to P contain the classification distribution of new as well as prior-service personnel. The user can also change the value in these cells, but the sum of these cells must be equal to one. For example, if the goal was to classify 80 percent with 0 YOS, 10 percent with less than 1 YOS, 5 percent with less than 2 YOS, and 5 percent with less than 3 YOS, then

$r_0 = .80$, $r_1 = .10$, $r_2 = .05$, $r_3 = .05$, and $r_4 = 0$. Column Q contains the total billet requirement for the particular PMOS. The user can change this number whenever the force structure or the PMOS requirement changes. To obtain the new classification forecasts, the user needs to perform only the following steps:

1. Adjust the value in column Q to reflect the new requirement for the PMOS.
2. If necessary, adjust the values in columns G to J and columns L to P.
3. Click the "Update" button with the mouse.

The operator can change just one PMOS or any number of them, and the spreadsheet will automatically compute the new annual classification input for each PMOS in columns B and K as well as the yearly stocks in columns C to F. Cell B217 displays the annual total classification for all the PMOS as shown in Figure B.1 of Appendix B.

C. HELPFUL HINT

From anywhere on the spreadsheet, the user can just push the "Home" button on the key board and the spreadsheet will return to cell A1, which is by the "Update" button. This quick short-cut saves time and eliminates the need to scroll up or page up through the spreadsheet.

APPENDIX B. LOTUS SPREADSHEET PROGRAMMING

In this appendix, the various procedures and commands that were used to create the revised steady state Markov model on the Lotus spreadsheet will be explained in further details.

A. SETTING UP THE MATRICES AND VECTORS ON THE LOTUS SPREADSHEET

In column A, PMOS 9919 is the last PMOS in the spreadsheet. Below this PMOS, there are five blocks which are associated with each particular PMOS. In Figure B.1, the five blocks of cells in the middle of the screen are used to demonstrate how the spreadsheet calculates the classification forecast for the PMOS 0121.

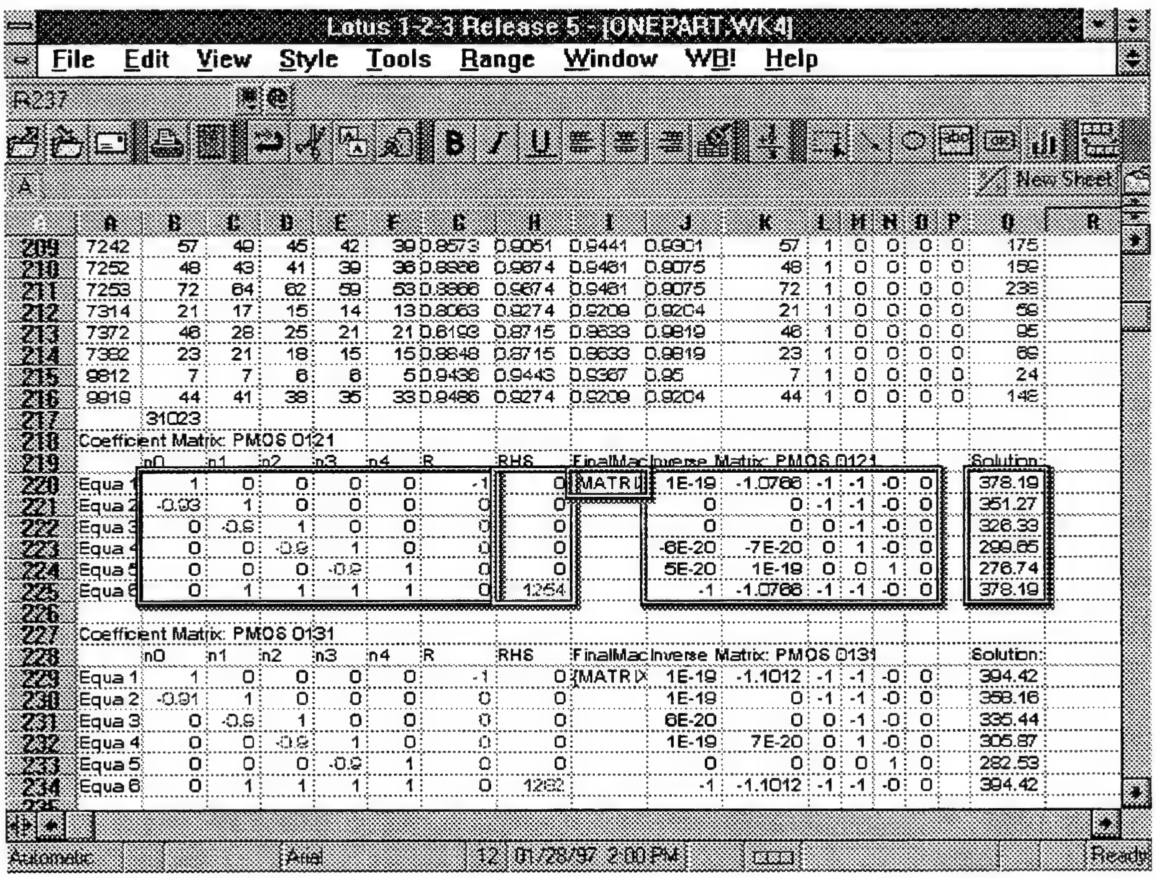


Figure B.1. Macro Command Example

- From left-to-right, the <u>first block</u> is the $\underline{A}$ matrix as discussed in Chapter IV Section A. This block was given the name of 0121COEFF. The cells B221, C222, D223, E224 are referenced from cells G9, H9, I9, J9, which are the yearly continuation rates for the PMOS 0121 as shown in Figure 4.1. Note that the continuation rates appear as negative numbers rounded to one or two decimal digits in this matrix due to the column spacing within the spreadsheet. However, in actuality these decimals are carried out to fifth digit within each cell. Whenever changes are made to cells G9, H9, I9, J9, the change also occurs automatically in cells B221, C222, D223, E224, respectively. Similarly, the values in cells G220, G221, G222, G223, G224 are referenced from the recruitment distribution for the PMOS 0121 in cells L9, M9, N9, O9, P9 in Figure 4.1. As before, any changes that are made in these latter cells will be transmitted to cells G220, G221, G222, G223, G224, respectively. On an actual computer screen, the values of these nine cells (B221, C222, D223, E224, G220, G221, G222, G223, G224) are displayed in red color. Note that the values in all the others cells in this block are to remain constant.
- The <u>second block</u> is the $\underline{b}$ vector discussed in Equation (4.1). In this spreadsheet, it was given the name of 0121RHS. Here, cell H225 is referenced from cell Q9, the total billet requirement for PMOS 0121 as shown in Figure 4.1. Similarly, any changes made to cell Q9 will affect cell H225 simultaneously. The value of cell H225 is also displayed in red on a computer monitor. The values of zero in the other four cells within this block must remain zero at all times.
- The <u>third block</u> contains the macro commands, which cause the computer to execute many of the arithmetic operations, and was given a cell name of 0121. Those macro commands will be explained in more detail in Section B.
- The <u>fourth block</u> contains the values of the inverse matrix, $\underline{A}^{-1}$, shown in Equation (4.1). This block was given the name of 0121NVER.

The <u>fifth block</u> contains the values of the $\underline{x}$ vector, the unknowns in Equation (4.1). The name of this block is 0121SOLU. These solutions are displayed rounded to the nearest integer in cells B9, C9, D9, E9, F9, K9 of Figure 4.1.

B. MACRO COMMANDS

The statements that were given in the third block contains these three Lotus macro commands:

{MATRIX-INVERT 0121COEFF;0121INVER}
{MATRIX-MULTIPLY 0121INVER;0121RHS;0121SOLU}
{0131}

The first statement is telling the computer to perform a matrix inverse operation on the cell block with the name of 0121COEFF and place the results in the cell block called 0121INVER. The second macro command is telling the computer to perform a matrix multiplication operation by taking the 0121INVER block and multiplying it by the block called 0121RHS, and then place the results in the cell block called 0121SOLU. The third statement simply tells the program to go to the cell named 0131, which is cell I229. This cell contains the macro commands for PMOS 0131, which are almost identical to the commands given for the PMOS 0121. So when the program reaches this cell, it will perform the same mathematical operations for the PMOS 0131. This process continues until the calculations for the last PMOS in the 01 OCCFLD has been completed. Then, the program switches back to the macro button to search for the next command to execute.

C. MACRO BUTTONS

The macro button, like the "Update" button in Figure B.2, can be created on a spreadsheet by clicking the Draw Macro SmartIcon and click the mouse at the worksheet location where you want to place the button. Reference 13 contains other technical information such as creating a special icon or wording within the button itself. To assign macro commands to a button, click the right button on the mouse and the menu as shown in Figure B.2 on the next page will appear.

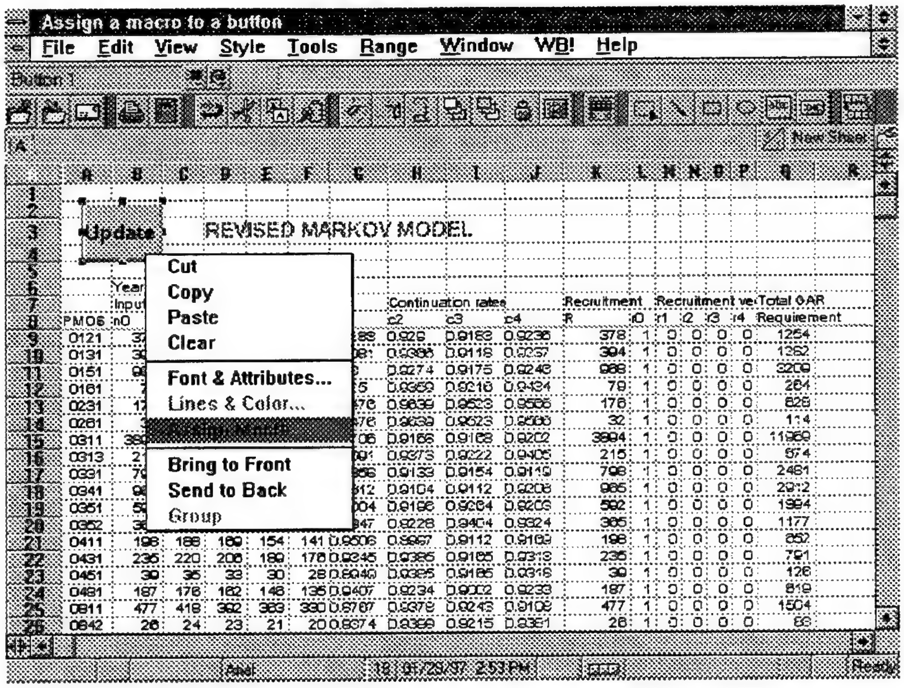


Figure B.2. Assign Commands to a Macro Button

Select the "Assign Macro..." subject, and the "Assign to Button" dialog box appears on the screen as shown in Figure B.3.

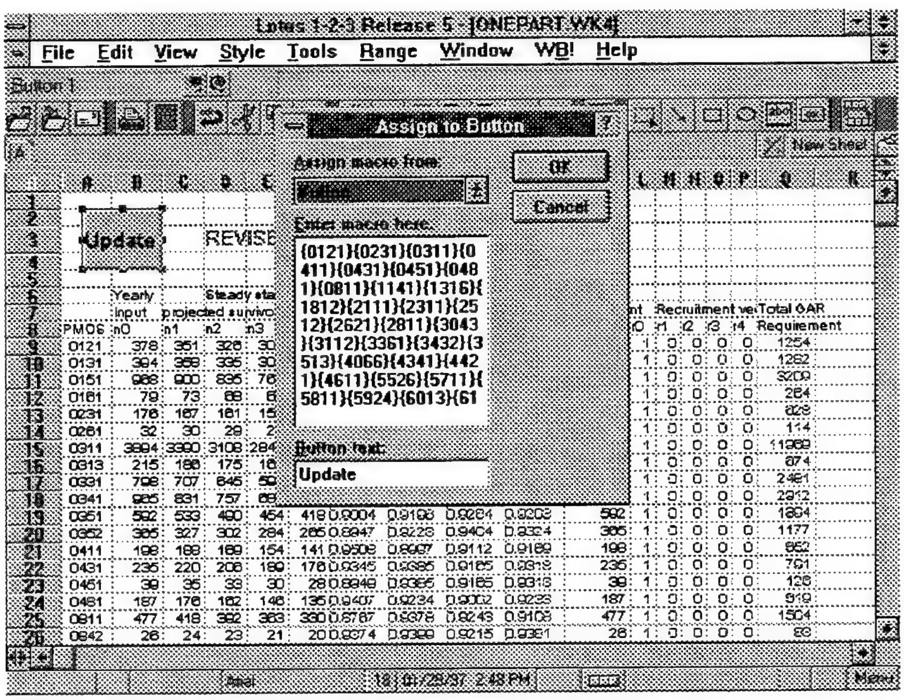


Figure B.3. Assign to Button Dialog Box

Approximately 175 macro commands can be placed directly into a macro button. Notice the command {0121} is the first statement placed in this macro button. This simple macro statement instructs the program to go to the cell named 0121, which is cell I220. There, it executes the macro commands within that cell, which were the computations for the PMOS 0121 as demonstrated earlier in this appendix. Once the computation is been completed for all the PMOS in the 01 OCCFLD, the computer executes the second macro command, {0231} shown in Figure B.3. The program goes to the cell indicated and performs the calculations for the all the PMOS in the 02 OCCFLD. This process continues until the calculations for the last PMOS have been accomplished. Although this is a very repetitive process, it takes a 486 or pentium micro-computer less than a minute to perform all the calculations for the entire 208 PMOS in this YOS system.

APPENDIX C. SAS CODINGS AND EXPLANATION

The files used in this research contained data on individuals, in the 01 and 65 OCCFLDs, who came on active-duty in the Marine Corps from FY 1986 to FY 1996. The SAS codings developed and used to analyze the attrition and continuation trend and to compute the average continuation rates in this study are listed in Section A. The detailed explanation relating to each specific step is included in Section B in this appendix.

A. SAS CODINGS

```
//FINAL    JOB USER=S9488,CLASS=A
//   EXEC SAS
//DATAIN1 DD DISP=SHR,DSN=MSS.C0143.VAN01
//DATAIN2 DD DISP=SHR,DSN=MSS.C0143.VAN65
//SYSIN DD *
OPTIONS LS=72;
******************** STEP 1 *********************;
****   READ IN RAW DATA FOR OCC FLD 0100     ****;
************************************************;
DATA MOS0100;
    INFILE DATAIN1;
        INPUT
            ENL_DAT      1-6
            YY           1-2
            MM           3-4
            DD           5-6
            COMP       $ 8-9
            RACE       $ 11
            ETHNIC     $ 13
            PEF        $ 15-16
            CONTLEN      18
            MARSTAT    $ 20
            CITIZEN    $ 22-23
            SEX        $ 25
            YRS_ED       27-28
            GT_SCORE     30-32
            EL_SCORE     34-36
            CL_SCORE     38-40
            MM_SCORE     42-44
            AFQT_PCT     46-47
            COHORT       49-50
            PEFGRP     $ 52-55
            PMOS         57-60
            IMOS       $ 62-65
            BMOS         67-70
            OCCFLD       72-73
            SEPDATE      75-79
;

******************** STEP 2 *********************;
****   READ IN RAW DATA FOR OCC FLD 6500     ****;
************************************************;
```

```
DATA MOS6500;
    INFILE DATAIN2;
        INPUT
            ENL_DAT      1-6
            YY           1-2
            MM           3-4
            DD           5-6
            COMP       $ 8-9
            RACE       $ 11
            ETHNIC     $ 13
            PEF        $ 15-16
            CONTLEN      18
            MARSTAT    $ 20
            CITIZEN    $ 22-23
            SEX        $ 25
            YRS_ED       27-28
            GT_SCORE     30-32
            EL_SCORE     34-36
            CL_SCORE     38-40
            MM_SCORE     42-44
            AFQT_PCT     46-47
            COHORT       49-50
            PEFGRP     $ 52-55
            PMOS         57-60
            IMOS       $ 62-65
            BMOS         67-70
            OCCFLD       72-73
            SEPDATE      75-79
;

******************** STEP 3 ********************;
***  COMBINE MOS0100 AND MOS6500 DATA SETS    ***;
************************************************;
DATA ALL;
   SET MOS0100 MOS6500;
   IF ENL_DAT EQ . THEN DELETE;

******************** STEP 4 ********************;
***            LABEL THE VARIABLES           ***;
************************************************;
LABEL ENL_DAT = 'ENLISTMENT DATE'
           YY = 'YEAR'
           MM = 'MONTH'
           DD = 'DAY'
         COMP = 'COMPONENT'
         RACE = 'RACE'
       ETHNIC = 'ETHNIC'
          PEF = 'PROGRAM ENLISTED FOR'
      CONTLEN = 'CONTRACT LENGTH'
      MARSTAT = 'MARITAL STATUS'
      CITIZEN = 'CITIZENSHIP'
          SEX = 'GENDER'
       YRS_ED = 'YEARS OF EDUCATION'
     GT_SCORE = 'ASVAB COMPOSITE FOR GT'
     EL_SCORE = 'ASVAB COMPOSITE FOR EL'
     CL_SCORE = 'ASVAB COMPOSITE FOR CL'
     MM_SCORE = 'ASVAB COMPOSITE FOR MM'
     AFQT_PCT = 'AFQT PERCENTILE'
       COHORT = 'FY MARINE ENTERED THE USMC'
       PEFGRP = 'OCCFLD GROUPING OF DIFFERENT PEF CODES'
         PMOS = 'PRESENT PRIMARY MOS OR ONE AT SEPARATION'
         IMOS = 'PRESENT INTENDED MOS OR ONE AT SEP'
         BMOS = 'PRESENT BILLET MOS OR AT AT SEPARATION'
       OCCFLD = 'FIRST TWO DIGITS OF PMOS'
```

```
      SEPDATE = 'SAS SEP DATE OR 1AUG96 IF STILL ON ACDU';

******************** STEP 5 *********************;
***  PRINT 25 OBSERVATIONS FROM EACH VARIABLE ***;
*************************************************;
DATA ZERO;
   SET ALL;
   N+1;
   IF N LE 25;
PROC PRINT DATA = ZERO;
TITLE 'TABLE A1 -- FIRST 25 OBSERVATIONS FROM EACH VARIABLE';
   VAR ENL_DAT COMP RACE ETHNIC PEF CONTLEN MARSTAT
       CITIZEN SEX YRS_ED GT_SCORE EL_SCORE CL_SCORE
       MM_SCORE AFQT_PCT COHORT PEFGRP PMOS IMOS BMOS
       OCCFLD SEPDATE;

******************** STEP 6 *********************;
***            PRINT FILE CONTENTS            ***;
*************************************************;
PROC CONTENTS DATA = ALL;
TITLE 'TABLE A2 -- CONTENTS OF BOTH DATA FILES';

******************** STEP 7 *********************;
***          PRINT A FEW FREQUENCIES          ***;
*************************************************;
PROC FREQ DATA = ALL;
   TABLES PMOS CONTLEN PEF;
TITLE 'TABLE A3 -- VARIOUS FREQUENCY TABLES';

******************** STEP 8 *********************;
***          DELETE COHORT 1996               ***;
*************************************************;
DATA ONE;
   SET ALL;
IF COHORT EQ 96 THEN DELETE;

******************** STEP 9 *********************;
*** REMOVE CONTRACT LENGTHS LESS THAN 4 YEARS ***;
*************************************************;
IF CONTLEN LT 4 THEN DELETE;

******************** STEP 10 ********************;
****      DISTRIBUTE RECRUITS -- 9900       ****;
*************************************************;
IF PMOS EQ 9900 THEN DO;
   RANNUM = RANUNI (1000);
   IF RANNUM GE 0 AND RANNUM LT .0568 THEN PMOS = 0100;
   ELSE IF RANNUM GE .0568 AND RANNUM LT .0717 THEN PMOS = 6500;
   ELSE IF RANNUM GE .0717 THEN DELETE;
END;

******************** STEP 11 ********************;
****      DISTRIBUTE RECRUITS -- 9971       ****;
*************************************************;
IF PMOS EQ 9971 THEN DO;
 IF PEF = 'Y1' OR PEF = '9A' OR PEF = '9L' THEN PMOS = 0100;
 ELSE IF PEF = 'YR' OR PEF = '65' OR PEF = '6W' THEN PMOS = 6500;
 ELSE DELETE;
END;

******************** STEP 12 ********************;
****        DISTRIBUTE 0100 AND 0193        ****;
*************************************************;
IF PMOS EQ 0193 THEN PMOS = 0100;
```

```
IF PMOS EQ 0100 THEN DO;
   RANNUM = RANUNI (1000);
   IF RANNUM GE 0 AND RANNUM LT .2207 THEN PMOS = 0121;
   ELSE IF RANNUM GE .2207 AND RANNUM LT .4400 THEN PMOS = 0131;
   ELSE IF RANNUM GE .4400 AND RANNUM LT .9573 THEN PMOS = 0151;
   ELSE IF RANNUM GE .9573 THEN PMOS = 0161;
END;

******************** STEP 13 ********************;
****    DISTRIBUTE 6500, 6511 AND 6591       ****;
************************************************;
IF PMOS EQ 6591 THEN PMOS = 6500;
IF PMOS EQ 6500 OR PMOS EQ 6511 THEN DO;
   RANNUM = RANUNI (1000);
   IF RANNUM GE 0 AND RANNUM LT .2621 THEN PMOS = 6521;
   ELSE IF RANNUM GE .2621 AND RANNUM LT .8056 THEN PMOS = 6531;
   ELSE IF RANNUM GE .8056 THEN PMOS = 6541;
END;

******************** STEP 14 ********************;
*** CONVERT ENLISTMENT DATE & COMPUTE YRSOFSRV **;
************************************************;
SASBEGDT = INT(((YY-60)*365.25)+(MM*(365.25/12))+DD);
YRSOFSRV = (SEPDATE+1-SASBEGDT)/365.25;

LABEL SASBEGDT = 'SAS ENLISTMENT DATE'
      YRSOFSRV = 'YEARS OF SERVICE';

******************** STEP 15 ********************;
****         FLAG SURVIVAL YEAR(S)           ****;
************************************************;
IF YRSOFSRV LT 0 THEN DELETE;
IF YRSOFSRV GE 0 THEN DO;
   SURVYR0 = 1; END;
IF YRSOFSRV GE 1 THEN DO;
   SURVYR1 = 1; END;
IF YRSOFSRV GE 2 THEN DO;
   SURVYR2 = 1; END;
IF YRSOFSRV GE 3 THEN DO;
   SURVYR3 = 1; END;
IF YRSOFSRV GE 3.75 THEN DO;
   SURVYR4 = 1; END;

LABEL SURVYR0 = 'ENTERED ACTIVE DUTY'
      SURVYR1 = 'SURVIVED YEAR 1'
      SURVYR2 = 'SURVIVED YEAR 2'
      SURVYR3 = 'SURVIVED YEAR 3'
      SURVYR4 = 'SURVIVED YEAR 4';

******************** STEP 16 ********************;
****  COMPARE PMOS & CONTLEN AFTER CLEAN-UP  ****;
************************************************;
PROC FREQ DATA = ONE;
   TABLES PMOS CONTLEN;
TITLE 'TABLE A4 -- PMOS & CONTLEN FREQUENCIES AFTER CLEAN-UP';

******************** STEP 17 ********************;
****  COMPUTE SURVIVOR SUM BY PMOS & YEAR    ****;
************************************************;
PROC SORT DATA = ONE;
   BY PMOS COHORT;
PROC MEANS DATA = ONE NOPRINT;
   VAR SURVYR0  SURVYR1  SURVYR2  SURVYR3  SURVYR4;
   OUTPUT OUT= ALPHA
```

```
      SUM = SUMR0 SUMR1 SUMR2 SUMR3 SUMR4;
   BY PMOS COHORT;

PROC PRINT DATA = ALPHA;
   TITLE 'TABLE A5 -- YEARLY SURVIVORS OF EACH COHORT';
   VAR PMOS COHORT SUMR0--SUMR4;

LABEL SUMR0 = 'SUM OF INITIAL ENTRY'
      SUMR1 = 'SUM OF YEAR 1 SURVIVORS'
      SUMR2 = 'SUM OF YEAR 2 SURVIVORS'
      SUMR3 = 'SUM OF YEAR 3 SURVIVORS'
      SUMR4 = 'SUM OF YEAR 4 SURVIVORS';

******************** STEP 18 ********************;
****   COMPUTE YEARLY CONTINUATION RATES     ****;
*************************************************;
DATA TWO;
   SET ALPHA;
   CONRATE1 = SUMR1/SUMR0;
   CONRATE2 = SUMR2/SUMR1;
   CONRATE3 = SUMR3/SUMR2;
   CONRATE4 = SUMR4/SUMR3;

LABEL CONRATE1 = 'YEAR 1 CONTINUATION RATE'
      CONRATE2 = 'YEAR 2 CONTINUATION RATE'
      CONRATE3 = 'YEAR 3 CONTINUATION RATE'
      CONRATE4 = 'YEAR 4 CONTINUATION RATE';

PROC PRINT DATA = TWO;
   TITLE 'TABLE A6 -- YEARLY CONTINUATION RATES';
   VAR PMOS COHORT CONRATE1--CONRATE4;

******************** STEP 19 ********************;
*** COMPUTE "AVERAGE" YEAR1 CONTINUATION RATE ***;
*************************************************;
DATA AAAA;
   SET ALPHA;
   IF COHORT EQ 95 THEN DO;
   SUMR0 = .; SUMR1 = .; END;

PROC MEANS DATA = AAAA NOPRINT;
   VAR SUMR0 SUMR1;
   OUTPUT OUT = CHARLIE
   SUM = YEAR0 YEAR1;
   BY PMOS;

DATA BBBB;
   SET CHARLIE;
   YEAR1CON = YEAR1/YEAR0;

******************** STEP 20 ********************;
*** COMPUTE "AVERAGE" YEAR2 CONTINUATION RATE ***;
*************************************************;
DATA CCCC;
   SET ALPHA;
   IF COHORT EQ 95 THEN DO; SUMR0 = .; SUMR1 = .; END;
   IF COHORT EQ 94 THEN DO; SUMR0 = .; SUMR1 = .; SUMR2 = .; END;

PROC MEANS DATA = CCCC NOPRINT;
   VAR SUMR1 SUMR2;
   OUTPUT OUT = DELTA
   SUM = YEAR1 YEAR2;
   BY PMOS;
```

```
DATA DDDD;
   SET DELTA;
   YEAR2CON = YEAR2/YEAR1;

******************** STEP 21 ********************;
*** COMPUTE "AVERAGE" YEAR3 CONTINUATION RATE ***;
*************************************************;
DATA EEEE;
   SET ALPHA;
   IF COHORT EQ 95 THEN DO; SUMR0 = .; SUMR1 = .; END;
   IF COHORT EQ 94 THEN DO; SUMR0 = .; SUMR1 = .; SUMR2 = .; END;
   IF COHORT EQ 93 THEN DO; SUMR0 = .; SUMR1 = .; SUMR2 = .;
      SUMR3 = .; END;

PROC MEANS DATA = EEEE NOPRINT;
   VAR SUMR2 SUMR3;
   OUTPUT OUT = FOXTROT
   SUM = YEAR2 YEAR3;
   BY PMOS;

DATA FFFF;
   SET FOXTROT;
   YEAR3CON = YEAR3/YEAR2;

******************** STEP 22 ********************;
*** COMPUTE "AVERAGE" YEAR4 CONTINUATION RATE ***;
*************************************************;
DATA GGGG;
   SET ALPHA;
   IF COHORT EQ 95 THEN DO; SUMR0 = .; SUMR1 = .; END;
   IF COHORT EQ 94 THEN DO; SUMR0 = .; SUMR1 = .; SUMR2 = .; END;
   IF COHORT EQ 93 THEN DO; SUMR0 = .; SUMR1 = .; SUMR2 = .;
      SUMR3 = .; END;
   IF COHORT EQ 92 THEN DO; SUMR0 = .; SUMR1 = .; SUMR2 = .;
      SUMR3 = .; SUMR4 = .; END;

PROC MEANS DATA = GGGG NOPRINT;
   VAR SUMR3 SUMR4;
   OUTPUT OUT = ECHO
   SUM = YEAR3 YEAR4;
   BY PMOS;

DATA HHHH;
   SET ECHO;
   YEAR4CON = YEAR4/YEAR3;

******************** STEP 23 ********************;
** MERGE "AVERAGE" CONTINUATION RATE DATA SETS **;
*************************************************;
DATA TOTAL;
   MERGE BBBB DDDD FFFF HHHH;
   BY PMOS;

LABEL YEAR1CON = 'YEAR 1 CONTINUATION RATE'
      YEAR2CON = 'YEAR 2 CONTINUATION RATE'
      YEAR3CON = 'YEAR 3 CONTINUATION RATE'
      YEAR4CON = 'YEAR 4 CONTINUATION RATE';

PROC PRINT DATA = TOTAL;
   TITLE 'TABLE A7 -- AVERAGE CONTINUATION RATES';
   VAR PMOS YEAR1CON YEAR2CON YEAR3CON YEAR4CON;
/*
//
```

B. DETAILED EXPLANATION

The top portion of the SAS file contains the Job Code Language (JCL) in order for the mainframe computer to execute the program. However, these were the general steps used in cleaning up the data, analyzing the attrition and continuation trend, and computing the average continuation rate for each PMOS by YOS:

- The first step was to read in the data from the flat file containing information on the individuals in the 01 OCCFLD. This file had 16,202 observations. Each observation pertains to an individual Marine.
- The second step was to read in the data from the 65 OCCFLD, which had 3,849 observations.
- The third step was to combine these two data files. The last observation from each file was deleted because they contained erroneous data, so the total number of observations from the two files was actually 20,049.
- The fourth step was to create label names for the variables. This procedure was also used in some of the other steps later in the program.
- The fifth step was to print the first 25 observations from each variable to see exactly what types of data the variables contained. The output is Table D.1 in Appendix D. Also, the definition for each variable is provided in Table C.1 on the next page.

Variable	Definition
ENL_DAT	Beginning date of current enlistment.
YY, MM, DD	ENL_DAT broken down to Year, Month, and Day of enlistment. Two numeric digits.
COMP	Component code.
RACE	Race code from Codes Manual.
ETHNIC	Ethnic code from Codes Manual.
PEF	Program enlisted for code.
CONTLEN	Contract length.
MARSTAT	Marriage code from Codes Manual.
CITIZEN	Citizen code from codes Manual.
SEX	Gender
YRS_ED	Years of education.
GT_SCORE	ASVAB composite score for GT.
EL_SCORE	ASVAB composite score for EL.
CL_SCORE	ASVAB composite score for CL.
MM_SCORE	ASVAB composite score for MM.
AFQT_PCT	AQFT percentile score.
COHORT	FY when the Marine entered the service.
PEFGRP	OCCFLD grouping of the different PEF codes.
PMOS	Present or primary MOS or one at separation.
IMOS	Present or intended MOS or one at separation.
BMOS	Present or billet MOS or one at separation.
OCCFLD	First two digits of PMOS.
SEPDATE	SAS date of either separation date or 1 Aug 96, if still on active-duty.
SEPTYPE	Categorizes separations type into one of four categories.

Table C.1. Variable Name and Definition

The cohort data files with all the variables provide a wealth of information on numerous topics, but only about half of the variables were used during our analysis and just a few of the variables were needed to compute the continuation rates.

- The sixth step was to print the contents of the data file. The output is Table D.2 in Appendix D.
- The seventh step was to print the frequency of the variables; PMOS, CONTLEN, and PEF. The output is Table D.3 in Appendix D. Notice in Table D.3, the PMOS 0100, 0193, 6500, 6511, 6532, 6542, 9900, and 9971 are listed. These are basic training, erroneous PMOS, or PMOS which are assigned to the staff non-commissioned officers in the Marine Corps, who are part of the CAREER force. Thus, the individuals in these PMOS must be distributed to one of the legitimate PMOS in this YOS system.
- The eighth step was to delete all the data from cohort FY 1996. Since the cutoff date for the data files was 1 August 1996, we did not have the complete continuation data on the FY 1996 cohort, so the information on this cohort was insufficient to perform any of the computations for this research.
- The ninth step was to delete all the observations with a CONTLEN of less than four years, because the YOS system is a FTERM, 4-year system. Allowing personnel with a CONTLEN of less than four years to be in the system would have affected the result of the computation of the continuation rates.
- The tenth step was to distribute the PMOS 9900. Since these individuals came into the Marine Corps under an open contract, we used a random number generator in SAS to distribute these individuals to the 01 or 65 OCCFLD, based on the OCCFLD's billet requirement as compared to the total FTERM billet requirements.
- The eleventh step was to distribute the PMOS 9971, based on the PEF code. If they were not pre-designated for the 01 or 65 OCCFLD, then they were deleted from the data file.
- The twelfth step was to distribute randomly the PMOS 0100 and 0193 to the PMOS 0121, 0131, 0151, or 0161, based on each PMOS' billet requirement as compared to the total requirement for the OCCFLD.

- The thirteenth step was to distribute randomly the PMOS 6500, 6511, and 6591 to the PMOS 6521, 6531, or 6541 PMOS, based on each PMOS' billet requirement as compared to the total requirement for the OCCFLD.
- The fourteenth step was to convert the ENL_DAT to a SAS numerical date, so the YRSOFSRV or YOS could be computed for each individual Marine.
- The fifteenth step was to flag each YRSOFSRV that the individual has completed. If the person had 3.25 YRSOFSRV, then he was considered as a survivor for years 1, 2, and 3 but not 4. Those who completed 3.75 years of service were considered to be survivors of year 4, because the Marine Corps has a policy of allowing Marines to separate from active-duty as early as ninety days before the end of their enlistment to attend school or assume some sort of public office. Also, sometimes when a Marine's enlistment contract expires on a weekend or holiday, he or she can elect to be discharged on the last work-day. [Ref. 14] These policy issues were taken into account to avoid the possibility of underestimating the year 4 continuation rate.
- The sixteenth step was to compare the new PMOS and CONTLEN tables with the old, after cleaning up the data files and distributing the individuals to the appropriate PMOS. The new PMOS and CONTLEN tables are shown in Table D.4 in Appendix D. All the individuals have been assigned to a legitimate PMOS or have been removed from the file.
- The seventeenth step was to compute the survivors by PMOS, cohort, and YRSOFSRV. The output is Table D.5 in Appendix D.
- The eighteenth step was to compute the continuation rates by PMOS and cohort. The year 1 continuation rate can be computed by dividing the number of survivors at the end of year 1 by the number of initial enlistees who were assigned to that PMOS, and the continuation rate for year 2 can be computed by dividing the number of survivors at the end of year 2 by the number of survivors at the end of year 1, and so on. The output is Table D.6 in Appendix D.
- Steps nineteen to twenty-two contain the codings for computing the average continuation rates for each PMOS. The year 1 average continuation rate can be computed by summing up all the survivors in each cohort to the end of the first year

and dividing that number by the sum of all new enlistees who entered that PMOS. The number of cohorts in the divisor must be equal to the number of cohorts in the numerator. For the year 1 continuation rate, only continuation data from cohorts 1986 to 1994 can be used in the calculation. Similarly, the year 2 average continuation rate can be computed by dividing the sum of the survivors at the end of year 2 by the sum of the survivors at the end of year 1, but excluding the data on cohorts 1994 and 1995, because the number of cohorts in the divisor must be the same as the number of cohorts in the numerator. The year 3 and year 4 average continuation rates can be calculated in the same manner by excluding the appropriate cohorts.

- Step twenty-three merges all the average continuation rates and displays them by PMOS in Table D.7 in Appendix D.

APPENDIX D. SAS LISTING "OUTPUT"

The tables shown below are part of the actual SAS listing. These tables are the outputs from the SAS program listed in Appendix C.

TABLE D.1 -- FIRST 25 OBSERVATIONS FROM EACH VARIABLE 1
14:24 Tuesday, February 4, 1997

OBS	ENL_DAT	COMP	RACE	ETHNIC	PEF	CONTLEN	MARSTAT	CITIZEN	SEX	YRS_ED	GT_SCORE	EL_SCORE	CL_SCORE
1	851002	11	C	Y	**	6	S	CA	M	12	0	0	.
2	851002	11	C	Y	**	6	S	CA	M	12	98	92	92
3	851002	11	N	Y	**	4	S	CA	M	12	118	114	110
4	851002	11	N	Y	00	3		CA	M	12	99	94	83
5	851002	11	C	Y	**	6	S	CA	M	12	91	96	111
6	851002	11	C	Y	**	4	S	CA	M	12	97	96	99
7	851002	11	C	Y	**	3	S	CA	M	12	130	124	121
8	851003	11	C	Y	**	4	S	CA	M	12	112	110	135
9	851003	11	C	Y	**	4	S	CA	M	12	98	94	137
10	851004	11	N	Y	**	4	S	CA	M	12	104	118	99
11	851004	11	C	Y	**	4	S	CA	M	12	74	86	76
12	851007	11	N	Y	**	6	S	CA	M	12	117	116	108
13	851007	11	N	Y	**	4	S	CA	M	12	90	94	86
14	851007	11	N	Y	**	4	S	CA	M	12	115	117	107
15	851008	11	C	4	**	4	S	CA	F	12	121	126	129
16	851008	11	C	Y	**	6	S	CA	F	12	152	143	.
17	851008	11	C	Y	**	6	S	CA	F	12	112	98	120
18	851008	11	N	Y	**	6	S	CA	F	12	77	92	81
19	851008	11	N	Y	**	6	S	CA	F	12	85	94	101
20	851008	11	C	Y	**	4	S	CA	F	12	113	116	120
21	851008	11	N	Y	**	6	S	CA	F	12	97	101	100
22	851008	11	C	Y	**	6	S	CA	F	12	111	0	.
23	851008	11	C	Y	**	6	S	CA	F	12	98	100	92
24	851008	11	C	Y	**	4	S	CA	F	12	85	99	76
25	851008	11	N	Y	**	6	S	CA	M	12	84	80	110

OBS	MM_SCORE	AFQT_PCT	COHORT	PEFGRP	PMOS	IMOS	BMOS	OCCFLD	SEPDATE
1	0	.	86	??	131		131	1	11596
2	98	0	86	??	193	0151	8411	1	13362
3	122	30	86	??	151		151	1	13362
4	77	20	86	OPEN	151		121	1	10504
5	82	50	86	??	151	3451	151	1	11555

6	98	50	86	??	151		193	1	13362
7	117	30	86	??	151		151	1	10500
8	100	60	86	??	161		161	1	10784
9	75	10	86	??	151		193	1	13362
10	117	80	86	??	151		151	1	12359
11	82	50	86	??	161		161	1	10822
12	122	70	86	??	121		121	1	10182
13	99	40	86	??	121		121	1	12081
14	114	0	86	??	193		193	1	13362
15	117	40	86	??	151		0	1	10241
16	133	0	86	??	193		193	1	13362
17	64	20	86	??	151		151	1	10241
18	93	40	86	??	161		161	1	9797
19	89	30	86	??	121		121	1	11732
20	122	.	86	??	161	0161	0	1	10652
21	67	30	86	??	121		121	1	11339
22	122	21	86	??	151		151	1	9770
23	95	0	86	??	151		151	1	10603
24	89	10	86	??	131		151	1	10934
25	85	30	86	??	161		161	1	11618

TABLE D.2 -- CONTENTS OF BOTH DATA FILES 2
14:24 Tuesday, February 4, 1997

CONTENTS PROCEDURE

```
 Data Set Name: WORK.ALL                           Observations:
20049
 Member Type:   DATA                               Variables:             25
 Engine:        V607                               Indexes:               0
 Created:       14:25 Tuesday, Feb 4, 1997         Observation Length:    146
 Last Modified: 14:25 Tuesday, Feb 4, 1997         Deleted Observations:  0
 Protection:                                       Compressed:            NO
 Data Set Type:                                    Sorted:                NO
 Label:

               -----Engine/Host Dependent Information-----

    Data Set Page Size:         23040
    Number of Data Set Pages:   128
    File Format:                607
    First Data Page:            1
    Max Obs per Page:           157
    Obs in First Data Page:     134
    Physical Name:              SYS97035.T140933.RA000.FINAL.R0011571
    Release Created:            6.07
    Release Last Modified:      6.07
    Created by:                 FINAL
    Last Modified by:           FINAL
    Subextents:                 2
    Total Blocks Used:          128

            -----Alphabetic List of Variables and Attributes-----
```

#	Variable	Type	Len	Pos	Label
18	AFQT_PCT	Num	8	90	AFQT PERCENTILE
23	BMOS	Num	8	122	PRESENT BILLET MOS OR AT AT SEPARATION
11	CITIZEN	Char	2	47	CITIZENSHIP
16	CL_SCORE	Num	8	74	ASVAB COMPOSITE FOR CL
19	COHORT	Num	8	98	FY MARINE ENTERED THE USMC
5	COMP	Char	2	32	COMPONENT
9	CONTLEN	Num	8	38	CONTRACT LENGTH
4	DD	Num	8	24	DAY

15	EL_SCORE	Num	8	66	ASVAB COMPOSITE FOR EL
1	ENL_DAT	Num	8	0	ENLISTMENT DATE
7	ETHNIC	Char	1	35	ETHNIC
14	GT_SCORE	Num	8	58	ASVAB COMPOSITE FOR GT
22	IMOS	Char	4	118	PRESENT INTENDED MOS OR ONE AT SEP
10	MARSTAT	Char	1	46	MARITAL STATUS
3	MM	Num	8	16	MONTH
17	MM_SCORE	Num	8	82	ASVAB COMPOSITE FOR MM
24	OCCFLD	Num	8	130	FIRST TWO DIGITS OF PMOS
8	PEF	Char	2	36	PROGRAM ENLISTED FOR
20	PEFGRP	Char	4	106	OCCFLD GROUPING OF DIFFERENT PEF CODES
21	PMOS	Num	8	110	PRESENT PRIMARY MOS OR ONE AT SEPARATION
6	RACE	Char	1	34	RACE
25	SEPDATE	Num	8	138	SAS SEP DATE OR 1AUG96 IF STILL ON ACDU
12	SEX	Char	1	49	GENDER
13	YRS_ED	Num	8	50	YEARS OF EDUCATION
2	YY	Num	8	8	YEAR

TABLE D.3 -- VARIOUS FREQUENCY TABLES 3
14:24 Tuesday, February 4, 1997

PRESENT PRIMARY MOS OR ONE AT SEPARATION

PMOS	Frequency	Percent	Cumulative Frequency	Cumulative Percent
100	664	3.3	664	3.3
121	3394	16.9	4058	20.2
131	3210	16.0	7268	36.3
151	8180	40.8	15448	77.1
161	669	3.3	16117	80.4
193	47	0.2	16164	80.6
6500	305	1.5	16469	82.1
6511	123	0.6	16592	82.8
6521	897	4.5	17489	87.2
6531	1763	8.8	19252	96.0
6532	1	0.0	19253	96.0
6541	745	3.7	19998	99.7
6542	1	0.0	19999	99.8
9900	7	0.0	20006	99.8
9971	43	0.2	20049	100.0

CONTRACT LENGTH

CONTLEN	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	1	0.0	1	0.0
2	1	0.0	2	0.0
3	42	0.2	44	0.2
4	16364	81.6	16408	81.8
5	666	3.3	17074	85.2
6	2975	14.8	20049	100.0

TABLE D.3 -- VARIOUS FREQUENCY TABLES 4
14:24 Tuesday, February 4, 1997

PROGRAM ENLISTED FOR

PEF	Frequency	Percent	Cumulative Frequency	Cumulative Percent
**	474	2.4	474	2.4
AE	349	1.7	823	4.1
AF	3	0.0	826	4.1
BA	7	0.0	833	4.2
BB	5	0.0	838	4.2
BC	10	0.0	848	4.2
BD	2881	14.4	3729	18.6
BE	19	0.1	3748	18.7
BF	5	0.0	3753	18.7
BG	20	0.1	3773	18.8
BH	25	0.1	3798	18.9
BI	10	0.0	3808	19.0
BK	1	0.0	3809	19.0
BL	19	0.1	3828	19.1
BM	7	0.0	3835	19.1
BP	14	0.1	3849	19.2
BQ	540	2.7	4389	21.9
BR	5	0.0	4394	21.9
BS	14	0.1	4408	22.0
BT	3	0.0	4411	22.0
BU	3	0.0	4414	22.0
BV	39	0.2	4453	22.2
BY	2	0.0	4455	22.2
B2	6	0.0	4461	22.3
B3	2	0.0	4463	22.3
CA	2	0.0	4465	22.3
CB	1493	7.4	5958	29.7
CE	5	0.0	5963	29.7
CJ	1	0.0	5964	29.7
CM	2	0.0	5966	29.8
DB	3	0.0	5969	29.8
DC	2	0.0	5971	29.8
D4	174	0.9	6145	30.6
D5	6	0.0	6151	30.7
GJ	1	0.0	6152	30.7
GS	1	0.0	6153	30.7
GT	58	0.3	6211	31.0
GU	6	0.0	6217	31.0
G2	21	0.1	6238	31.1
G6	5	0.0	6243	31.1
PA	1	0.0	6244	31.1
PC	30	0.1	6274	31.3
PE	1	0.0	6275	31.3
PF	9	0.0	6284	31.3
PG	1	0.0	6285	31.3
PJ	13	0.1	6298	31.4
P1	1	0.0	6299	31.4
P5	3	0.0	6302	31.4
P9	1	0.0	6303	31.4
UB	9	0.0	6312	31.5
UC	6	0.0	6318	31.5
UD	4027	20.1	10345	51.6
UE	17	0.1	10362	51.7
UF	2	0.0	10364	51.7
UG	10	0.0	10374	51.7
UH	63	0.3	10437	52.1
UJ	1	0.0	10438	52.1
UK	2	0.0	10440	52.1
UL	20	0.1	10460	52.2
UM	27	0.1	10487	52.3
UP	19	0.1	10506	52.4

UQ	855	4.3	11361	56.7
UR	9	0.0	11370	56.7
US	31	0.2	11401	56.9
UT	4	0.0	11405	56.9
UV	41	0.2	11446	57.1
UW	2	0.0	11448	57.1
UX	7	0.0	11455	57.1
UY	4	0.0	11459	57.2
U2	5	0.0	11464	57.2
WM	47	0.2	11511	57.4

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PEF	Frequency	Percent	Cumulative Frequency	Cumulative Percent
WS	1	0.0	11512	57.4
WU	1	0.0	11513	57.4
WV	1	0.0	11514	57.4
WY	1	0.0	11515	57.4
WZ	1	0.0	11516	57.4
W8	1	0.0	11517	57.4
YA	1	0.0	11518	57.4
YC	3	0.0	11521	57.5
YD	9	0.0	11530	57.5
YE	1	0.0	11531	57.5
YH	1	0.0	11532	57.5
YL	1	0.0	11533	57.5
YQ	1	0.0	11534	57.5
YR	343	1.7	11877	59.2
YS	1	0.0	11878	59.2
YU	1	0.0	11879	59.2
YV	9	0.0	11888	59.3
Y1	1375	6.9	13263	66.2
Y2	1	0.0	13264	66.2
Y3	13	0.1	13277	66.2
Y7	4	0.0	13281	66.2
Y9	5	0.0	13286	66.3
00	3841	19.2	17127	85.4
1Q	1	0.0	17128	85.4
1T	4	0.0	17132	85.5
1X	3	0.0	17135	85.5
19	2	0.0	17137	85.5
2J	1	0.0	17138	85.5
2N	1	0.0	17139	85.5
23	1	0.0	17140	85.5
27	1	0.0	17141	85.5
28	55	0.3	17196	85.8
29	1	0.0	17197	85.8
3B	4	0.0	17201	85.8
3H	1	0.0	17202	85.8
3R	5	0.0	17207	85.8
31	3	0.0	17210	85.8
32	13	0.1	17223	85.9
33	18	0.1	17241	86.0
35	2	0.0	17243	86.0
4A	4	0.0	17247	86.0
4B	6	0.0	17253	86.1
41	1	0.0	17254	86.1
45	7	0.0	17261	86.1
5J	1	0.0	17262	86.1

5M	1	0.0	17263	86.1
6A	203	1.0	17466	87.1
6L	1	0.0	17467	87.1
6M	1	0.0	17468	87.1
6N	16	0.1	17484	87.2
6P	1	0.0	17485	87.2
6Q	34	0.2	17519	87.4
6S	2	0.0	17521	87.4
6U	1	0.0	17522	87.4
6V	107	0.5	17629	87.9
6W	3	0.0	17632	87.9
6X	75	0.4	17707	88.3
6Y	1	0.0	17708	88.3
62	1	0.0	17709	88.3
63	2	0.0	17711	88.3
64	4	0.0	17715	88.4
65	412	2.1	18127	90.4
67	11	0.1	18138	90.5
68	17	0.1	18155	90.6
7A	1	0.0	18156	90.6
7L	1	0.0	18157	90.6
7M	3	0.0	18160	90.6
7N	38	0.2	18198	90.8
7P	1	0.0	18199	90.8
7R	1	0.0	18200	90.8
71	3	0.0	18203	90.8

TABLE D.3 -- VARIOUS FREQUENCY TABLES 6
14:24 Tuesday, February 4, 1997

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PEF	Frequency	Percent	Cumulative Frequency	Cumulative Percent
75	1	0.0	18204	90.8
8H	3	0.0	18207	90.8
8K	2	0.0	18209	90.8
8L	3	0.0	18212	90.8
8R	1	0.0	18213	90.8
8S	44	0.2	18257	91.1
8X	2	0.0	18259	91.1
85	1	0.0	18260	91.1
9A	42	0.2	18302	91.3
9L	1715	8.6	20017	99.8
9R	7	0.0	20024	99.9
9S	18	0.1	20042	100.0
9X	3	0.0	20045	100.0
9Y	4	0.0	20049	100.0

TABLE D.4 -- PMOS & CONTLEN FREQUENCIES AFTER CLEAN-UP 7
14:24 Tuesday, February 4, 1997

PRESENT PRIMARY MOS OR ONE AT SEPARATION

PMOS	Frequency	Percent	Cumulative Frequency	Cumulative Percent
121	3368	17.9	3368	17.9
131	3191	16.9	6559	34.8
151	8016	42.5	14575	77.3
161	665	3.5	15240	80.8

6521	942	5.0	16182	85.8
6531	1878	10.0	18060	95.8
6541	794	4.2	18854	100.0

CONTRACT LENGTH

CONTLEN	Frequency	Percent	Cumulative Frequency	Cumulative Percent
4	15232	80.8	15232	80.8
5	655	3.5	15887	84.3
6	2967	15.7	18854	100.0

TABLE D.5 -- YEARLY SURVIVORS OF EACH COHORT 8
14:24 Tuesday, February 4, 1997

OBS	PMOS	COHORT	SUMR0	SUMR1	SUMR2	SUMR3	SUMR4
1	121	86	270	266	241	214	189
2	121	87	337	318	282	256	230
3	121	88	365	354	327	294	258
4	121	89	408	394	356	323	284
5	121	90	359	348	320	286	257
6	121	91	191	186	173	155	139
7	121	92	330	325	302	280	245
8	121	93	388	375	342	203	.
9	121	94	311	294	207	.	.
10	121	95	409	280	.	.	.
11	131	86	268	251	225	206	187
12	131	87	366	351	320	289	267
13	131	88	296	284	260	237	213
14	131	89	351	329	308	279	248
15	131	90	296	283	257	228	196
16	131	91	287	275	253	221	201
17	131	92	306	297	276	257	225
18	131	93	312	303	290	164	.
19	131	94	345	329	236	.	.
20	131	95	364	253	.	.	.
21	151	86	668	643	591	533	472
22	151	87	715	679	630	562	524
23	151	88	882	854	774	713	632
24	151	89	909	882	803	724	640
25	151	90	861	815	757	690	607
26	151	91	570	546	497	457	394
27	151	92	591	579	538	493	449
28	151	93	1211	1167	1081	779	5
29	151	94	801	770	454	.	.
30	151	95	808	476	.	.	.
31	161	86	90	87	85	75	69
32	161	87	45	45	41	38	37
33	161	88	79	75	65	56	49
34	161	89	71	70	66	60	55
35	161	90	62	61	55	48	43
36	161	91	54	52	44	40	39
37	161	92	75	74	72	67	61
38	161	93	52	52	46	29	1
39	161	94	75	73	52	.	.
40	161	95	62	50	.	.	.
41	6521	86	82	81	76	73	67

42	6521	87	100	96	94	87	81
43	6521	88	87	84	75	69	63
44	6521	89	88	86	77	73	65
45	6521	90	101	100	91	86	81
46	6521	91	98	95	92	86	75
47	6521	92	93	89	77	71	67
48	6521	93	120	116	108	66	.
49	6521	94	79	75	52	.	.
50	6521	95	94	61	.	.	.
51	6531	86	96	91	87	81	72
52	6531	87	184	172	163	157	148
53	6531	88	239	232	220	206	195
54	6531	89	261	256	241	221	204
55	6531	90	146	144	135	126	115
56	6531	91	144	139	127	116	107
57	6531	92	156	151	138	129	121
58	6531	93	154	152	142	88	3
59	6531	94	232	221	125	.	.
60	6531	95	266	178	.	.	.
61	6541	86	62	60	58	56	50
62	6541	87	104	100	95	93	87
63	6541	88	94	88	82	76	73
64	6541	89	86	83	73	63	58
65	6541	90	63	61	57	50	47
66	6541	91	90	86	83	75	70
67	6541	92	90	89	85	79	73
68	6541	93	85	85	75	52	.
69	6541	94	64	54	46	.	.
70	6541	95	56	29	.	.	.

TABLE D.6 -- YEARLY CONTINUATION RATES 9
14:24 Tuesday, February 4, 1997

OBS	PMOS	COHORT	CONRATE1	CONRATE2	CONRATE3	CONRATE4
1	121	86	0.98519	0.90602	0.88797	0.88318
2	121	87	0.94362	0.88679	0.90780	0.89844
3	121	88	0.96986	0.92373	0.89908	0.87755
4	121	89	0.96569	0.90355	0.90730	0.87926
5	121	90	0.96936	0.91954	0.89375	0.89860
6	121	91	0.97382	0.93011	0.89595	0.89677
7	121	92	0.98485	0.92923	0.92715	0.87500
8	121	93	0.96649	0.91200	0.59357	.
9	121	94	0.94534	0.70408	.	.
10	121	95	0.68460	.	.	.
11	131	86	0.93657	0.89641	0.91556	0.90777
12	131	87	0.95902	0.91168	0.90313	0.92388
13	131	88	0.95946	0.91549	0.91154	0.89873
14	131	89	0.93732	0.93617	0.90584	0.88889
15	131	90	0.95608	0.90813	0.88716	0.85965
16	131	91	0.95819	0.92000	0.87352	0.90950
17	131	92	0.97059	0.92929	0.93116	0.87549
18	131	93	0.97115	0.95710	0.56552	.
19	131	94	0.95362	0.71733	.	.
20	131	95	0.69505	.	.	.
21	151	86	0.96257	0.91913	0.90186	0.88555
22	151	87	0.94965	0.92784	0.89206	0.93238
23	151	88	0.96825	0.90632	0.92119	0.88640
24	151	89	0.97030	0.91043	0.90162	0.88398
25	151	90	0.94657	0.92883	0.91149	0.87971
26	151	91	0.95789	0.91026	0.91952	0.86214
27	151	92	0.97970	0.92919	0.91636	0.91075
28	151	93	0.96367	0.92631	0.72063	0.00642
29	151	94	0.96130	0.58961	.	.

30	151	95	0.58911	.	.	.
31	161	86	0.96667	0.97701	0.88235	0.92000
32	161	87	1.00000	0.91111	0.92683	0.97368
33	161	88	0.94937	0.86667	0.86154	0.87500
34	161	89	0.98592	0.94286	0.90909	0.91667
35	161	90	0.98387	0.90164	0.87273	0.89583
36	161	91	0.96296	0.84615	0.90909	0.97500
37	161	92	0.98667	0.97297	0.93056	0.91045
38	161	93	1.00000	0.88462	0.63043	0.03448
39	161	94	0.97333	0.71233	.	.
40	161	95	0.80645	.	.	.
41	6521	86	0.98780	0.93827	0.96053	0.91781
42	6521	87	0.96000	0.97917	0.92553	0.93103
43	6521	88	0.96552	0.89286	0.92000	0.91304
44	6521	89	0.97727	0.89535	0.94805	0.89041
45	6521	90	0.99010	0.91000	0.94505	0.94186
46	6521	91	0.96939	0.96842	0.93478	0.87209
47	6521	92	0.95699	0.86517	0.92208	0.94366
48	6521	93	0.96667	0.93103	0.61111	.
49	6521	94	0.94937	0.69333	.	.
50	6521	95	0.64894	.	.	.
51	6531	86	0.94792	0.95604	0.93103	0.88889
52	6531	87	0.93478	0.94767	0.96319	0.94268
53	6531	88	0.97071	0.94828	0.93636	0.94660
54	6531	89	0.98084	0.94141	0.91701	0.92308
55	6531	90	0.98630	0.93750	0.93333	0.91270
56	6531	91	0.96528	0.91367	0.91339	0.92241
57	6531	92	0.96795	0.91391	0.93478	0.93798
58	6531	93	0.98701	0.93421	0.61972	0.03409
59	6531	94	0.95259	0.56561	.	.
60	6531	95	0.66917	.	.	.
61	6541	86	0.96774	0.96667	0.96552	0.89286
62	6541	87	0.96154	0.95000	0.97895	0.93548
63	6541	88	0.93617	0.93182	0.92683	0.96053
64	6541	89	0.96512	0.87952	0.86301	0.92063
65	6541	90	0.96825	0.93443	0.87719	0.94000
66	6541	91	0.95556	0.96512	0.90361	0.93333
67	6541	92	0.98889	0.95506	0.92941	0.92405
68	6541	93	1.00000	0.88235	0.69333	.
69	6541	94	0.84375	0.85185	.	.
70	6541	95	0.51786	.	.	.

TABLE D.7 -- AVERAGE CONTINUATION RATES 10
14:24 Tuesday, February 4, 1997

OBS	PMOS	YEAR1CON	YEAR2CON	YEAR3CON	YEAR4CON
1	121	0.96654	0.91309	0.90355	0.88809
2	131	0.95578	0.92246	0.90416	0.89863
3	151	0.96213	0.91987	0.90893	0.88992
4	161	0.97678	0.91860	0.89720	0.92429
5	6521	0.96934	0.92369	0.93643	0.91139
6	6531	0.96650	0.93717	0.93249	0.93054
7	6541	0.95664	0.93252	0.92308	0.93220

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